

Designing and Testing an Experimental Framework of Affective Intelligent Agents in Healthcare Training Simulations

MICHAEL LOIZOU

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This thesis is dedicated to my family

To my lovely wife Dana who supported me through difficult times, my beautiful children Ariadne and Stefanos whose hugs made the tiredness disappear and my parents Ploutis and Tasoula who were there for me whenever I needed them.

Table of Contents

ABSTRACT	1
1. INTRODUCTION.....	2
1.1. Introduction of the Research Context	2
1.2. Research question and objectives	3
1.3. Thesis Contributions	4
1.4. Thesis Outline.....	5
1.5. Summary	6
2. LITERATURE REVIEW.....	7
2.1 Psychology of emotions.....	7
2.1.1 Emotions and stress	9
2.1.2 Appraisal theory	10
2.1.3 Prevalent emotions in the health sector.....	11
2.2 Affective Virtual Agent design.....	13
2.2.1 Emotion oriented computing.....	13
2.2.2 Using the BDI model for affective Virtual Agent Design.....	18
2.2.3 Incorporating emotions into virtual tutors	24
2.2.4 Personality types.....	28
2.2.5 Text based emotion communication.....	33
2.2.6 Using facial expressions for communicating emotions.....	34
2.2.7 Using sounds for communicating emotions.....	37
2.2.8 Using emoticons for communicating emotions.....	38
2.3 Dementia	39

2.4	Markup Languages	40
2.4.1	Background.....	41
2.4.2	Commonly used markup languages.....	41
2.4.3	The future.....	43
2.5	Summary	44
3. DESIGN OF THE EMOTIONAL VIRTUAL AGENT'S ARCHITECTURE FOR VIRTUAL PATIENTS IN INTERACTIVE TRAINING SOFTWARE		45
3.1	Architecture design	46
3.2	Beliefs, Desires, and Intentions Model.....	58
3.3	The reasoning module – Rules Engine.....	59
3.4	Emotional Intelligence for Virtual Agent Design	61
3.5	Summary	63
4.	METHODOLOGY	64
4.1	Research Design	64
4.2	Data Collection and manipulation	66
4.3	Ethical Issues and Study Limitations	68
4.3.1	Ethical considerations.....	68
4.3.2	Limitations.....	69
4.4	Summary	69
5.	EVALUATION.....	70
5.1	Qualitative data coding	71
5.2	Analysis and Discussion of the qualitative data	73
5.2.1	Participant information and initial interview.....	73
5.2.2	Thematic Analysis.....	84

5.3 Summary	108
6. CONCLUSIONS AND FUTURE WORK	109
REFERENCES	113
APPENDIX 2 – PERSONALITY ASSESSMENT TOOL	133
APPENDIX 3: SEMI-STRUCTURED INTERVIEWS	135
APPENDIX 4 – PARTICIPANT INFORMATION STATEMENT AND CONSENT FORM.....	136
APPENDIX 5 – SAMPLE SCENARIO	137

List of Figures

Figure 2.1 - Basic emotions in various theories (Ortony and Turner 1990).....	8
Figure 2.2 – Psychoevolutionary theory of basic emotions (Plutchik 1982)	9
Figure 2.3 – The PEFiC model (Van Vugt, Hoorn et al. 2004) ...	17
Figure 2.4 – Agent design for the Virtual Humans project (Kenny, Hartholt et al. 2007).....	20
Figure 2.5 – Goal hierarchy of an explainable BDI agent (Harbers, van den Bosch et al., 2009).....	20
Figure 2.6 – Goal hierarchy of an leading firefighter agent (Harbers, van den Bosch et al., 2009).....	21
Figure 2.7 – BDI tutor model (Florea and Kalisz 2005)	22
Figure 2.8 – IVA Architecture (Van Oijen, Van Doesburg et al.)..	23
Figure 2.9 – Ontology example based on IVA (Van Oijen, Van Doesburg et al.).....	23
Figure 2.10 – Model Social Game Agent (MSGa) model (Johansson, Verhagen <i>et al.</i> , 2011)	24
Figure 2.11 – Variables relating to mental states and emotions (Heylen, Nijholt et al. 2005)	24
Figure 2.12 - The agents and components of the tutor element in INES	25
Figure 2.13 - Architecture for agents with behaviour influenced by personality and emotions	26
Figure 2.14 – Architecture of AITS	27
Figure 2.15 – The emotional tutor, Emilie-1.....	27
Figure 2.16 – Summary of animation properties for some.....	34

Figure 2.17 - Components of widely recognised facial expressions (Smith and Scott 1997)	35
Figure 2.18 - Architecture for the intelligent expressions.....	36
Figure 2.19 - Facial expressions of Greta (Ochs, Niewiadomski et al. 2005)	36
Figure 2.20 - Universal emotions and possible expressions (Fitrianie and Rothkrantz 2006).....	36
Figure 2.21 - System architecture (Fitrianie and Rothkrantz 2006)	37
Figure 3.1: High-level overview of the proposed Emotional Virtual Agent's Architecture.	48
Figure 3.2 - A screenshot of the virtual environment generated by the Unity 3D game engine. In this screenshot the user is inputting their emotional scale and is communicating with the tutor	51
Figure 3.3- A screenshot of the virtual environment generated by the Unity 3D game engine. In this screenshot the user is inputting their emotional scale and is communicating with the virtual patient	51
Figure 3.4 – Algorithm for adjusting the self-reporting of emotions	53
Figure 3.5 – Algorithm for creating random world events,	53
Figure 3.6 - Use of animations, sounds and emoticons for portraying the emotion of happiness for the virtual patient.....	54
Figure 3.7 - Use of animations, sounds and emoticons for portraying the emotion of sadness for the virtual patient.....	55
Figure 3.8 - Use of animations, sounds and emoticons for portraying the emotion of disgust for the virtual patient.....	55
Figure 3.9 - Use of animations, sounds and emoticons for portraying the emotion of fear for the virtual patient.....	56

Figure 3.10 - Use of animations, sounds and emoticons for portraying the emotion of anger for the virtual patient.....	56
Figure 3.11 - An overview of the rules system used by JBOSS (http://www.jboss.org).....	60
Figure 3.12 - The Inputs to the Rule System as customised for our design.....	60
Figure 3.13 – Algorithm for adjusting the responses of the virtual agent depending on the participant's personality traits and emotions.....	63

ABSTRACT

The purpose of this study is to investigate how emotionally enabled virtual agents (VAs) in healthcare provision training simulations allow for a more effective level of understanding on how an emotionally enhanced scenario can affect different aspects of learning. This is achieved by developing virtual agents that respond to the user's emotions and personality. The developed system also provides visual and auditory representations of the virtual agents' state of mind.

To enable the fulfilment of this purpose an experimental framework for incorporating emotional enhancements (concentrating on negative emotions such as stress, fear, and anxiety) into virtual agents in virtual training applications for healthcare provision is designed and implemented. The framework for incorporating emotional enhancements is designed based on previous research, on psychological theories (with input by experienced psychologists) and from input of experts in the area of healthcare provision.

For testing the framework and answering the research question of this thesis the researcher conducted nine case studies. The participants were nursing students in the area of healthcare provision, and more specifically in the area of mental health, specialising in caring for patients with dementia.

The results of the study showed that the framework and its implementation succeeded in providing a realistic learning experience, stimulated a better set of responses from the user, improved their level of understanding on how an emotionally enhanced scenario can affect the learning experience and helped them become more empathetic towards the person they cared for.

1. Introduction

This chapter introduces the aims and objectives of this research and presents the research context, the study rationale and the research contributions of this work. Section 1.1 introduces the research context, section 1.2 states the aims and 1.3 the thesis' contributions to the field. Focusing on the area of training simulations for healthcare provision, this research study will create a suitable experimental framework for embedding emotions into virtual agents (VAs) and enable them to respond to users' emotions and investigate the effect of this framework on the believability of the VAs responses and on the learning of the end user.

1.1. Introduction of the Research Context

Creating virtual simulations for training users is not a trivial task. A specialist user has to be able to, in real time, control the simulation by adding, removing and/or modifying objects to suit different scenarios (Araujo, Rocha et al. 2008). VAs can be used for controlling these simulations but, for ensuring that their responses are both realistic and efficient, systems must not rely on deterministic techniques, such as finite-state machine techniques and scripts that lead to machine driven responses and resulting in frustration for the end user (Martin *et al.* 2012).

Trainees using these simulations are likely to be under stress, defined as perceived threat caused by environmental factors, often accompanied by a number of basic emotions such as anger, fear, distress, surprise, and disgust (Evans-Martin 2007). Currently, however, machines that interact with human users do not take into consideration these emotions when responding to user input (Schröder and Cowie 2006).

To be able to provide affective interaction between VAs and human users, the computer system needs to provide the virtual agents with capabilities for emotional and socially intelligent behaviour which should be able, in real time, to have a measurable effect on the effective state of the user

(Prendinger and Ishizuka 2005). Towards this end, the aims and objectives of this thesis are outlined in the following section.

In this thesis, it was decided to test the experimental framework by focusing its application in the area of dementia care. One reason that this area was chosen is the need of research to support the emotional and physical well-being of the UK's ageing population with growing numbers of people with dementia (Alzheimer's Society, 2015). More importantly, as the testing of our framework will focus on negative emotions, scenarios in the area of dementia are a good match as caring for a person with dementia often leads to feelings of loneliness, grief, anger and resentment (Shah et. al, 2010).

1.2. Research question and objectives

The research question (RQ) formulated for this work reads as follows:

RQ – How can the incorporation of emotions into autonomous software agents in virtual training applications allow for a more effective level of understanding on how an emotionally enhanced scenario can affect different aspects of learning?

To answer this research question the following objectives (RO's) will be addressed:

RO1 - The development of an experimental framework for embedding emotions into virtual agents in virtual training applications for healthcare provision.

RO2 - The development of a prototype implementation of the emotional virtual agent experimental framework in virtual training applications for healthcare provision.

RO3 - The investigation of if a virtual learning scenario incorporating emotional virtual agents provides a realistic experience.

RO4 - The investigation of if the incorporation of emotions into virtual agents stimulates a better set of responses from the human user.

RO5 - The investigation of if emotional virtual agents can have an effect on the learning experience.

RO6 - The investigation of if emotional virtual agents allow the learners to recognise their emotions and understand how these affect the virtual agents and, subsequently, allow them to feel more empathy towards them.

1.3. Thesis Contributions

This research provides the following contribution to the field:

The design of an experimental framework based on the BDI (Beliefs, Desires, Intentions) model that takes into consideration the emotions and personality of the user, in addition to scenario events. The developed system outputs an action to be taken by the agent and a set of appropriate visual and auditory instructions (e.g. commands to determine which animations, facial expressions, emoticons and sounds to be played by the agent).

The experimental framework was implemented by developing a system that can be adapted for use in many diverse areas of training. This system consists of:

1. a 3D virtual learning environment programmed using Unity3D
2. a JAVA back-end based on the BDI model enhanced with a rules engine (using the DROOLS rules management system) to support emotional and personality inputs and visual/auditory outputs.

This system can be adapted for use in various applications in the area of serious games.

For testing the system, we designed and implemented a scenario that can be used for training formal carers of people with dementia using an online learning environment.

A set of case studies and their evaluation for providing qualitative data supporting that the framework, the system and the scenarios can provide a realistic experience, stimulate a better set of responses, improve the level of

understanding on how an emotionally enhanced scenario can affect different aspects of learning and increase the empathy of the carers. By the term “realistic experience” we refer to how the training system/scenario as a whole compares to what the trainees would expect to encounter in real life. It is a combination of the scenario, the virtual character’s responses and the virtual learning environment (visual and auditory feedback). In this thesis, the trainees are 3rd year nursing students but this could vary in future implementations of the experimental framework.

1.4. Thesis Outline

The remaining chapters of this thesis are organised as follows. Chapter 2 introduces the psychology of emotions, describing appraisal theory and prevalent emotions in the health sector. This is followed by a section on affective virtual agent design which introduces emotion oriented computing and the desires and intentions model (BDI) before describing ways of incorporating emotions into virtual tutors. It then continues to discuss different personality types and ways for communicating emotions, which include text, facial expressions, sounds, and emoticons. The following section introduces dementia and technological interventions for supporting carers of people with dementia. The final section of this chapter describes different ways of storing and retrieving emotion related data.

Chapter 3 presents the architecture used for creating a virtual agent that alters its mood and behaviour based on the responses, personality and emotions of the human user. We illustrate the architecture and introduce the Jboss DROOLS Expert rules engine and the Behaviours Desires and Intentions (BDI) model which were used for building the experimental framework and prototype of our system.

Chapter 4 describes the methodology used for this thesis. The research design is clearly described along with data collection and manipulation. Ethical issues and study limitations are listed.

Chapter 5 presents the evaluation of the data. The qualitative data are coded and are split into different sections, using thematic analysis, for describing how the final four research objectives of this research have been met.

Finally, chapter 6 summarises and concludes this thesis and proposes what could be done in the future to further improve the model and implementation developed in this research.

1.5. Summary

This chapter briefly introduced virtual simulations and virtual agents and the need to endow them with the capability to modify their responses based on the user's emotions. The research question and objectives have been outlined and the key contributions of this research paper have been listed. Finally, the thesis has been outlined by summarising the remaining chapters.

2. Literature Review

This chapter introduces psychological theories describing emotions and focuses on negative emotions that are more likely to cause stress. It also introduces appraisal theory and explains how emotions can be affected by diverse appraisals of the same situation. Prevalent emotions in the health sector are then discussed and examples provided. The section on affective virtual agent design introduces emotion oriented computing and provides a discussion on various research projects that designed models for incorporating emotions into virtual agents. The desires and intentions model (BDI) is introduced and projects that used the BDI model for designing affective virtual agents are critically assessed. Section 2.2.5 introduces different personality type models before choosing the best suited one to be used for this study. The following few sections describe different ways for communicating emotions which include text, facial expressions, sounds, and emoticons. Section 2.3 introduces dementia and discusses how technological interventions can support carers of people with dementia, help them improve their well-being and have positive effects on how they care for a person with dementia. The last section of this chapter describes ways of storing and retrieving emotion related data in virtual training environments. Finally, markup languages and techniques are compared in order to determine how they can be used in this research.

2.1 *Psychology of emotions*

Emotions affect the way people feel, think, and behave in different contexts and situations (Haselton and Ketelaar 2006). Even though emotions and feelings are related, they are not the same. Emotions, such as anger, fear and pain can lead, individually or in a combination, to a complex range of feelings which might themselves manifest a number of behaviours. These behaviours can stem from a combination of emotions, feelings and previous experiences (Gislason 2011).

Philosophers and psychologists separate emotions into primary and secondary. Primary emotions such as fear, sadness and anger are supposed

to be instinctive and are the response to an immediate condition, i.e. danger. Secondary emotions on the other hand, for example joy and relief, arise from higher cognitive processes and are based on what we perceive that the result of a certain situation will be, that is the expected outcome based on the evaluation of the current state of events (Damasio 1994). Different philosophers and psychologists propose the number of primary emotions to be between 3 and 11, some examples can be seen in Figure 2.1. For example (Ekman 1984) lists five basic emotions whereas (Plutchik 2001) expands these to eight, in addition to listing the secondary emotions that can stem from them (Figure 2.2).

Author	Primary (Basic) Emotions
Darwin	Happiness, sadness, fear, disgust, anger, surprise
Ekman et al.	Joy, sadness, fear, disgust, anger, surprise
Izard	Anger, contempt, disgust, distress, fear, guilt, interest, joy, shame, surprise
Oatley et al.	Anger, disgust, anxiety, happiness, sadness
Plutchik	Acceptance, anger, anticipation, disgust, joy, fear, sadness, surprise
Tomkins	Anger, interest, contempt, disgust, distress, fear, joy, shame, surprise

Figure 2.1 - Basic emotions in various theories (Ortony and Turner 1990)

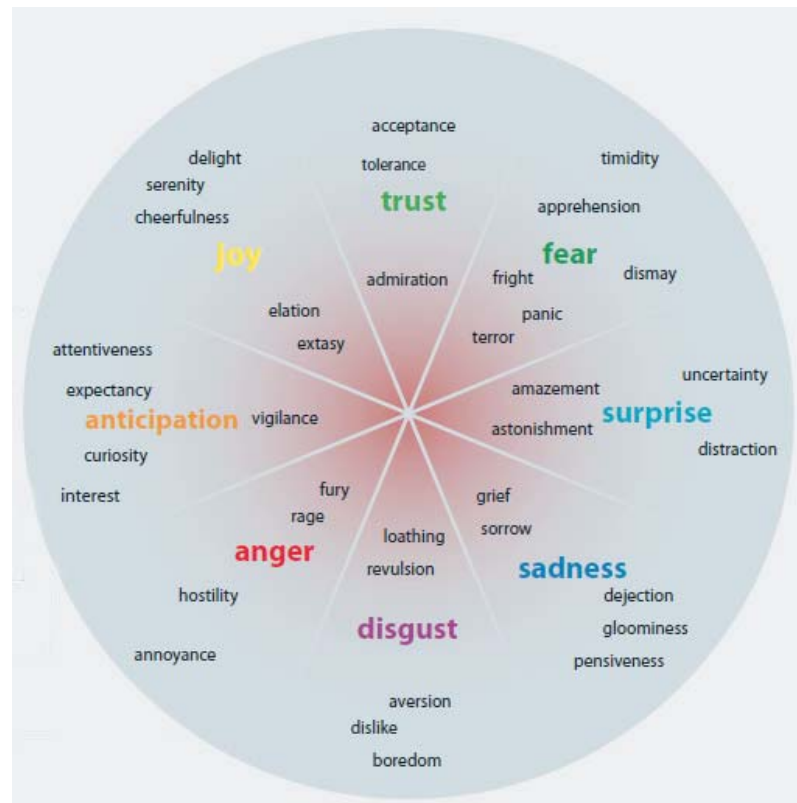


Figure 2.2 – Psychoevolutionary theory of basic emotions (Plutchik 1982)

2.1.1 Emotions and stress

Stress can be defined as a “perceived threat” caused by factors within our environment, usually referred to as stressors. Stressors can be either physical (for example, a hurricane or a dangerous dog) or psychological (for example, an argument with a family member or a new job). Emotions are an important part of stress as stressors usually create a range of accompanying emotions (Evans-Martin 2007). Some of the emotions that are likely to induce stress are defined below (Strongman 1987):

- Anger – usually viewed as a negative emotion, especially when it is part of aggression and violence, but can also be positive when it prepares a person for defence;
- Anxiety and fear – both negative and very distressing emotions, separated by the fact that anxiety is a more unclear emotion as to where it stems from whereas fear is usually connected with something external and more tangible;

- Sadness – usually seen as a little less tense than the rest of the negative emotions. It can interact with shame, anger and fear;
- Disgust – a feeling that is usually connected with the rejection of something, either physiological or psychological. Can be associated with the feeling of contempt and it is a clearly a human-only negative emotion;
- Jealousy and envy – Jealousy is the fear of losing the affection of someone important to us and that affection might be directed towards another person. Envy is wanting to have something that belongs to someone else, either a physical possession or a personal characteristic;
- Shame – along with embarrassment and guilt it is a social emotion and deals with how we conform to set rules and how we pursue goals.

2.1.2 Appraisal theory

Appraisal theory is based on the notion that emotions are prompted by appraisals, or evaluations, of situations and events. According to these theories differences in emotions can be due to diverse appraisals as a situation can be interpreted in a number of ways. These appraisals can be either conscious or unconscious and evaluations from these two levels do sometimes conflict with each other. In addition to this appraisals of a certain situation may also change over time, causing an alteration of the emotions that stem from them (Scherer, Schorr et al. 2001).

Appraisal theorists support that the emotions caused by an event or a range of events can be predicted if there is an understanding of how the event was being appraised. Based on this, researchers can construct scenarios that match theoretical appraisal profiles and correlate the feelings reported by participants to the baseline feelings of the profiles. Disadvantages of appraisal theory methods include a typically heavy reliance on verbal means for collecting data as some participants might find it difficult to accurately explain their emotions. There are cases where non-verbal means are used for collecting data, but appraisal theory's dependence on self-report

mechanisms still has its disadvantages i.e. knowing whether these reports are a reflection of the actual experience or of what the participant later recollects that he/she experienced (Ellsworth and Scherer 2003). Using psychological theories for designing computing systems for human-machine interaction is part of what is called 'Emotion oriented computing'.

2.1.3 Prevalent emotions in the health sector

According to Dillon (2008), family members of patients in the intensive care unit can be seen as being in a state of crisis and have to deal with a number of emotions. These emotions grow the longer they are held inside and can make people burst out. That makes it more likely for personnel of the intensive care units to be the target of rage, blame and anger. It is, thus, important to make sure that the personnel are appropriately trained for dealing with such difficult situations.

Medical personnel also need to deal with strong patient feelings such as rage, fear and tears when coming to terms with difficult situations i.e. an unwanted pregnancy, infertility, or cancer diagnosis. According to the author an "Emotions formula" can be used for calculating the level of emotion that the patient will feel: **$LPE = (O + LIS + PT + LES)$** where **LPE**=Level of Painful Emotion, **O**=Opportunity to express the emotion, **LIS**=Lack of Internal Strategies, **PT**=Perceived Threat of trigger, and **LES**=Lack of External Support. Health professionals have the opportunity to alter the level of painful emotion by changing any of the elements in the formula. They should, therefore, be trained to work with opportunity, encourage self-calming, lower perceived threat, and maximise external support (Quilliam 2008).

A questionnaire was developed in Norway for measuring patients' experience of interaction, emotion and consultation outcomes in primary health care. Patients' replies supported the notion that their emotions were rarely addressed during their visits but they appreciated it when they were. Personnel found it difficult to deal with patients' emotions, especially when these were difficult to express, in particular when these were negative and

directed, many times unfairly, towards other people for example when these emotions consisted of extreme anger and frustration (Steine, Finset et al. 2001).

According to Rippon (2000), anger in health care environments is a very common emotion and health care professionals are exposed to it on a daily basis with an increasing number of them suffering from signs of post-traumatic stress disorder. A study by Alexander and Klein (2001) identified high levels of burnout, general psychopathology, and posttraumatic symptoms in 33% of a group of ambulance personnel exposed to accidents, emergency work and critical incidents. Burnout was associated with the time they have been in service, job satisfaction, recovery time between incidents and how frequently personnel were exposed to incidents. In addition to the psychological effects on health personnel, physiological risks of intense emotional conflicts are also outlined by Theorell, Ahlberg-Hulten et al. (1993). Their research indicates that there is a strong relationship between blood pressure and job-strain of female health care personnel. Saunders and Valente (1994) also reported that nurses that care for terminally ill patients reported difficulty in managing grief, receiving psychological support at work, and talking with colleagues about their grief. According to the authors this may be due to the limited practical preparation the nurses receive for coping with emotional stress and patients' death.

Managing patients' feelings in addition to their own feelings is a very important aspect of the necessary skills of nurses and other health personnel. For improving the skills of their emotional competency, training using scripted scenarios and other management techniques can be used (Bone 2002). Nurse managers also play a pivotal role in managing nurses' stress, improving their coping behaviours, creating a work environment that supports emotion induced stress, and modelling the way for how nurses should cope (Shirey 2006).

In the area of health care (Kizakevich, Furberg et al. 2006) discuss the importance of training personnel in recognising, and responding to, the

emotions of patients for health care resource allocation in disasters where these resources are limited. Virtual characters in the training environment should be able to portray fright, anger, confusion and other emotions or behaviours based on cognitive, physiological, pathological and emotional models.

For the training of critical care personnel, emotionality of the scenario is of primary importance for achieving a high enough level of realism. Using the 'Circumplex Model of Emotion', a two dimensional structure that includes 16 core affects which combined cover all emotional states of an individual at any given time, Foot (2007) attempts to maximize experiential learning based on a combination of, predominantly, positive emotions combined with some negative emotions. The authors support that a combination of both positive and negative emotions is needed to maximise learning. The authors stress though that the introduction of negative emotions into the training environment should be done with care as there is always the danger of these emotions being triggered in situations when the participants are re-exposed to a similar situation in reality.

The proposed framework of this thesis aims to cater for negative emotions that the trainee feels during stressful online scenarios e.g. in the area of dementia care. This will, partly, be achieved by giving the opportunity to the trainees to express their emotions during the training session and also show them using visual and auditory clues how their emotional state and actions affect the virtual patients. In addition to the above, a personality test taken by the participants before they take part in the scenarios will provide the researcher with the level of neuroticism of each individual. This neuroticism score will also be used to personalise the feedback provided to each trainee during the enhanced virtual training scenario.

2.2 *Affective Virtual Agent design*

2.2.1 Emotion oriented computing

Even though it is increasingly accepted that emotions are an important factor in improving human-machine interaction, many times digital systems do not take into account the emotional dimension that human users expect to

encounter in an interaction and this can lead to frustration (Schröder and Cowie 2006). To be able to provide affective interaction between VAs and human users, the computer system needs to provide the virtual agents with capabilities for emotional and socially intelligent behaviour which should be able, in real time, to have a measurable effect on the affective state of the user (Prendinger and Ishizuka 2005).

There are few studies that examine the potential of digitally generating believable emotions and moods in human-machine interactions. For example, a paper by Gebhard and Kipp (2006) evaluates how plausible computer generated emotions are in textual dialogs between humans and virtual agents. The emotions and moods were generated in real time by a computational model, ALMA (A Layered Model of Affect). For testing the ability of ALMA to produce human comparable affect, a group of 33 participants was asked to judge 24 emotions and 8 moods on their plausibility through a selection of dialogs, which were pre-evaluated by a panel of experts (a dialog expert, a computer linguist, and a psychologist). The results showed that the participants found the emotions and moods provided by the system to be plausible. One of the limitations of the paper is the usage of questionnaires as the only mean of collecting data from the participants which, being a self-reporting measurement, can lead to subjective replies.

Recent research on agent architectures and emotions for virtual training of personnel for stressful situations focuses on emotion integration, the design of virtual agents that interact with other agents (virtual or real) based on social norms and on how to improve agent realism and believability. Towards this goal some of the research combines and/or extends other theories and models such as BDI, PSI (Dörner, 2013), OCC (Clore & Ortony, 2013), and FFM (Five factor Model). For example the extended BDI (EBDI) model (Jiang, Vidal et al. 2007) is an extension of the BDI model and adds the influence of primary and secondary emotions. This makes agents more engaging and believable so that they can better play a human-like role in virtual scenarios. The initial results from this model using Tileworld (an

experimental environment for evaluating agent architectures) are promising. However, as Tileworld is a system that involves only virtual agents, more research using virtual environments and scenarios that include real humans, in addition to virtual agents, is needed to determine the degree to which the EBDI model improves agent believability in addition to performance.

The DETT model (Van Dyke Parunak, Bisson et al. 2006) supplements BDI with the addition of elements of the OCC model to account for differences in emotional vulnerability of agents in stressful situations. Results were promising in implemented software and in war-game experiments showing that agents' dispositions corresponded to their emotions and directly affected how they responded to external triggers. For example, if a soldier with a disposition for cowardice feels fear due to an incoming attack, he is more likely to try and avoid the threat and less likely to follow orders. Future work could improve on this by expanding possible associations, for example the connection between emotion and desire.

ORIENT (Aylett, Kriegel et al. 2009) is a comprehensive model with elements from BSI, OCC, and PSI, adding components such as motivation, cognition, perception, learning and memory. Even though it has a promising potential, further work is needed for making sure that autobiographic memory is used for determining future actions of the agents rather than solely determining their need for certainty and their need for competence.

Another group includes models and simulations that were designed based on social and organizational models in conjunction with psychological theories. These models and simulations look in more detail at how agents act based on their environment, other agents, and social interactions. The EMotion and Adaptation (EMA) model (Marsella and Gratch 2006) is based on the Appraisal Theory and focuses on how emotions affect the ways in which agents cope in different scenarios. EMA did have some positive results from testing the model but the use of abstract scenarios and only self-reporting for data gathering are some of its limitations. Future work could take into consideration individual differences in appraisal and coping for further improvement of the model. This would make the agents act more

realistically as in a real life scenario humans would cope with a stressful situation in different ways based on their individual characteristics, something that this model does not currently cater for.

Drillsim (Balasubramanian, Massaguer et al. 2006) is a simulation that centres on how real people interact with other agents and the environment by taking into consideration four entities: Data, Knowledge, Information, and Wisdom. Drillsim works well in scenarios with a large number of agents but does not incorporate any models of emotions or takes into account the possibility of interaction between real people and agents. Future work could include incorporating emotions, primarily negative ones, more likely to be triggered in stressful situations. A combination of the established psychological models discussed in this paper could be applied and then tested using a scenario with human participants.

Agent-Group-Role (Ferber, Gutknecht et al. 2004) and Tropos (Silva, Maciel et al. 2007) focused more on how common goals and co-operation can shape agent interaction but had difficulties in identifying groups without analysing goals, tasks, and roles.

Finally, Masbiole (Eguchi, Hirasawa et al. 2006) added the factor of Symbiosis in the mix where agents evolve to modify their objectives and strategies taking into consideration the benefits and losses of both themselves and their opponents. The system tested the theoretical model using a synthetic simulation. Further research is needed for testing the integration of Masbiole with models dealing with the social interaction between humans and agents and verifying how effective it can be in real life situations.

Mixed emotions are also something to be considered when designing empathic virtual agents. These are believed to be blends of basic emotions, for example fear and surprise can generate alarm whereas joy and fear would generate guilt (Plutchik 1994). A study by Larsen compared the reporting of emotions between two groups of participants, one that watched a video clip of a combination of pleasant and unpleasant scenes and another

that watched a clip of bittersweet scenes. The group that watched the bittersweet clip spent more time reporting happy and sad emotions simultaneously (by pressing buttons labelled sad and happy at exactly the same time) (Larsen and McGraw 2011).

The Simultaneous Emotion Elicitation Model (SEEM) is a model of mixed emotion for designing virtual agents able to concurrently elicit emotions and take them into consideration in the decision making mechanism. A limitation of this paper is that only ambivalence, one of the most frequent mixed emotions, is discussed (Lee, Kao et al. 2006).

Focusing on several emotions at the same time the Perceiving and Experiencing Fictional Characters (PEFiC) model (Figure 2.3) describes the cognitive processes which are accompanied by the different emotions. The model divides the process into three distinct phases: encoding, comparison and response. Encoding places the fictional character on an ethical dimension (good-bad), aesthetics (beauty-ugliness) and epistemics (realistic-unrealistic). The comparison phase establishes personal valence towards the character in addition to similarity towards him. This valence and similarity will influence the user response be it involvement, distance, or a combination of the two (Van Vugt, Hoorn et al. 2004)

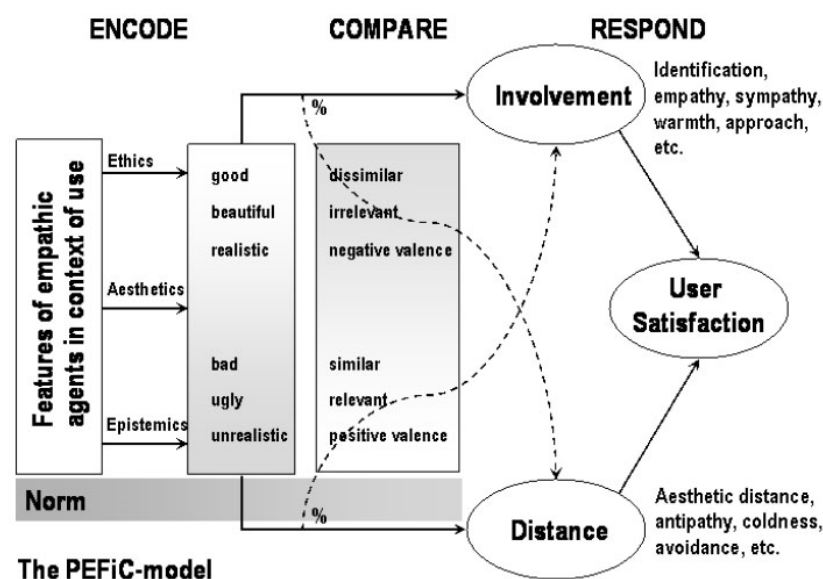


Figure 2.3 – The PEFiC model (Van Vugt, Hoorn et al. 2004)

A lot of work is still needed in the future as there is not a 'fit-all' model or theory that can be used for the design of affective virtual agents. More theoretical models for the creation of agents that will possess the necessary range of emotions for stressful situations need to be designed and tested. Agents designed using these models should be able to, in real time, respond to human participants' emotions in a socially intelligent way and have a measurable effect to the participants' effective state. There is a limited amount of current research that focuses on agents' responses to negative emotions, which are more relevant in highly stressful situations that many times arise in the healthcare provision sector. To achieve these goals future work should focus on how emotions are associated with other variables such as expectations, coping and desires, personality and its effect on emotions, and agent behaviour in multi-agent environments. Furthermore, research could also address how these systems are affected by concepts such as symbiosis, collective behaviour and social norms. Research on how agents act, cope, and respond to other agents (human or virtual) during crises is very important as successful collaboration between agents in stressful and demanding situations is much more difficult to predict and control.

2.2.2 Using the BDI model for affective Virtual Agent Design

One of the most widely accepted models in the area of agent design, BDI, has also been used for creating autonomous agents with a level of human reasoning and decision making. By interpreting the beliefs, desires, plans, and intentions of the agent, the model programmed the following aspects into the agents: Compassionate Intelligence, Affective Inference, Belief change, Human Reasoning, Intuition and Decision making (Biswas, 2011).

The dMARS™ development and implementation environment was created for developing intelligent agents in the area of battlefield simulations (Evertsz and Ronnquist 1998). Using the BDI model, support was incorporated for proactive, time-critical responses to change and goal-directed behaviour. The internal state of every agent was characterized by a set of beliefs about the environment and other agents, desires/goals to be achieved, plans describing the actions to be used for achieving the goals or reacting to

certain situations, and an intention structure comprising of all the possible plans to be executed.

The Land Operations Division, DSTO, of the Australian department of defence also used BDI for developing Command Agents that are able to model the behaviours of company commanders in wargames. The JACK Teams modelling framework was used for designing the command agent layer that allows the agents to take instructions, understand their context, plan an operation and assign tasks to other agents, and receive information from the wargame scenario and use this for responding to unexpected situations (Lui, Connell et al. 2002).

EQ-Rescue (EarthQuake-Rescue) was created for optimising resource allocation after strong earthquakes. EQ-Rescue is a distributed simulation system that consists of three components: simulators for the disaster environment, e.g., simulators for casualties, simulators for personnel operations and technical equipment, and auxiliary simulators. BDI was, again, used for agent creation in the EQ-Rescue model. Agents' behaviour was controlled by events within the agent that affect the reasoning process, external events (environmental changes, agent communication), and motivation events that create the goal set for each agent (Fiedrich 2006).

The Virtual Humans project at the Institute for Creative Technologies (ICT) is using BDI for creating agents (please see Figure 2.4) to serve as guides, competitors, mentors and teammates in training simulations for skills such as negotiation, interviewing, leadership and cultural training. BDI is being used for creating agents that are believable, responsive and interpretable. Agents are expected to display emotion and interact with the environment (Kenny, Hartholt et al. 2007)

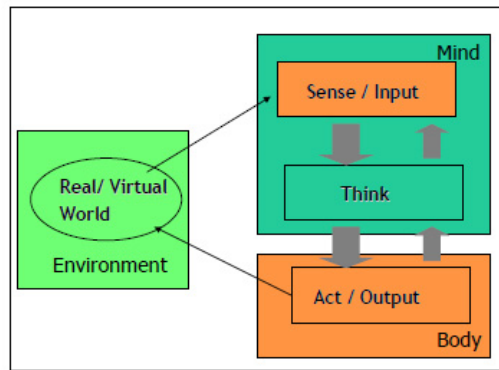


Figure 2.4 – Agent design for the *Virtual Humans project* (Kenny, Hartholt et al. 2007)

Explainable BDI agents can help decrease mistakes in critical situations but making trainees aware of their actual mental states. This way the agents will display a more realistic human behaviour and provide an effective way of training people for complex and dynamic tasks. Figures 2.5 and 2.6 below show the goal hierarchy of an explainable BDI agent and an example of the implementation of this goal hierarchy for a fire-fighter agent (Harbers, van den Bosch et al., 2009).

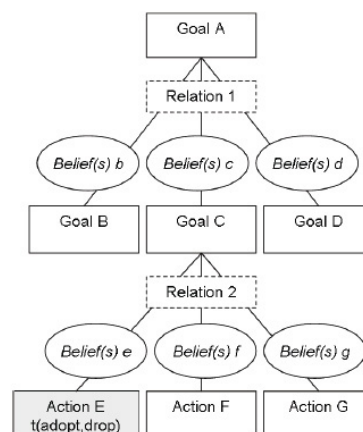


Figure 2.5 – Goal hierarchy of an explainable BDI agent (Harbers, van den Bosch et al., 2009)

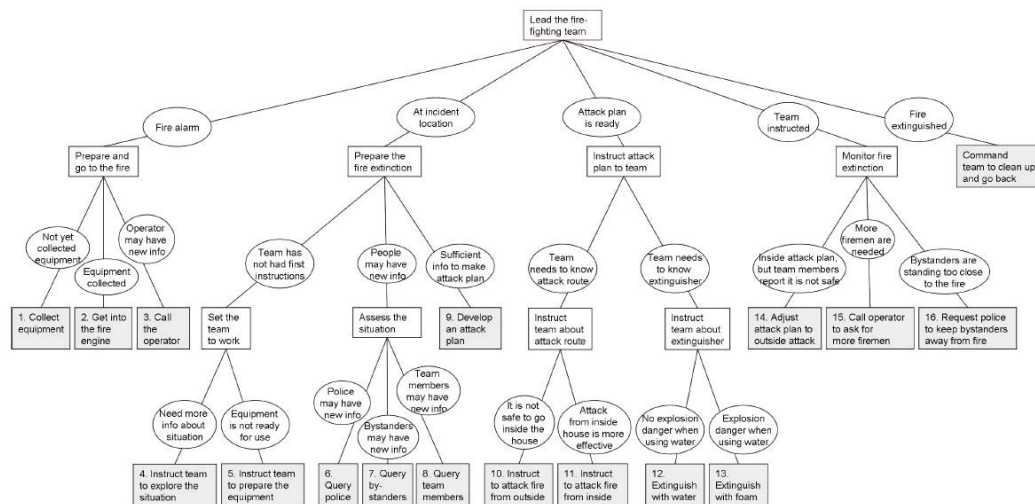


Figure 2.6 – Goal hierarchy of an leading firefighter agent (Harbers, van den Bosch et al., 2009)

(Engelmann 2007) discusses the EOC-TRAINER and EOCADVISOR components of the training simulation for an earthquake emergency operation centre (EOC). The agent environment is built as a multi-agent system (MAS) and the decision support agents are designed using a combination of the BDI model and an inference engine. The inference engine is using expert knowledge stored in a database with inference rules. Based on these rules the current agent situation is analysed and a decision is made. This can enhance the response possibilities over an approach that only uses BDI rules.

Even though emotions play an important role in planning, decision making, cognition and learning, many e-learning systems do not take them into consideration. Florea and Kalisz (Florea and Kalisz 2005) designed a model, based on the BDI architecture, that can tailor its behaviour towards students based on their reactions and their presumed affective states. In Figure 2.7 we can see that the tutor modifies the presentation and questions so that they respond to the cognitive side of the student actions and try to either sustain positive emotions or prevent negative ones. For further developing the model emotional intensity and memory could be integrated into it and tests on real subjects are needed for evaluating its effectiveness.

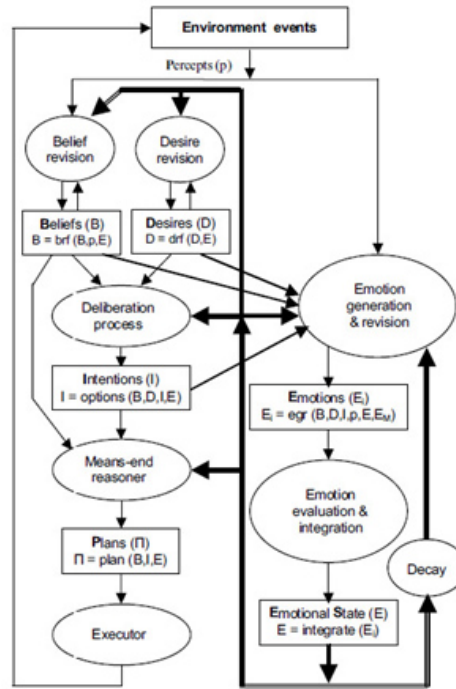


Figure 2.7 – BDI tutor model (Florea and Kalisz 2005)

Harbers (Harbers, Van den Bosch et al. 2009) developed intelligent agents that can compare the estimated mental states of agents to their actual ones. Towards this goal they extended the BDI architecture with the concept of Theory of Mind (ToM). Entities designed with ToM attributes allow trainees to experience how others interpret the way they behave and helps them train on how to cope with people that might make false assumptions regarding their goals and beliefs.

Training fire-fighting commanders on how to communicate with, control and command the members of their team is one of the most important aspects of fire-fighting training simulations. A large number of Subject Matter Experts (SMEs) is needed and, if real humans are used, this makes it both costly and time consuming. An alternative is to use virtual agents for playing the key roles in the simulation. In this project BDI agents are used, created with the Jadex multi-agent BDI platform. In figure 2.8 we can see the architecture of the Intelligent Virtual Agent (IVA) and figure 2.9 shows an example of an ontology based on this architecture (Van Oijen, Van Doesburg et al., 2011)

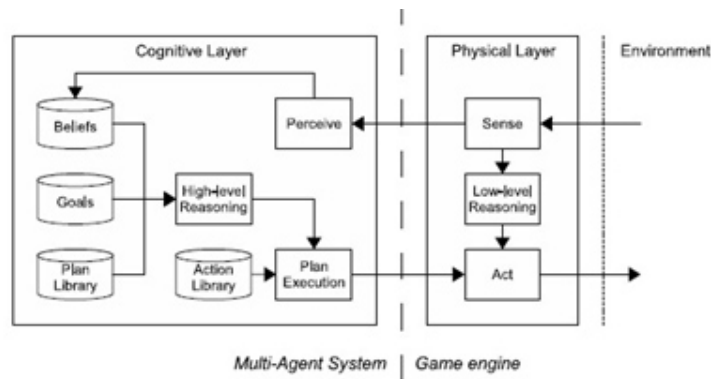


Figure 2.8 – IVA Architecture (Van Oijen, Van Doesburg et al.)

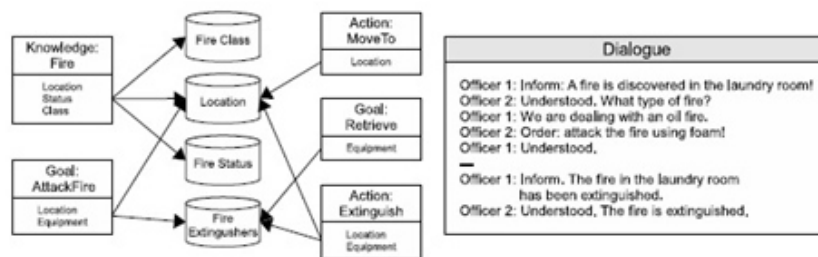
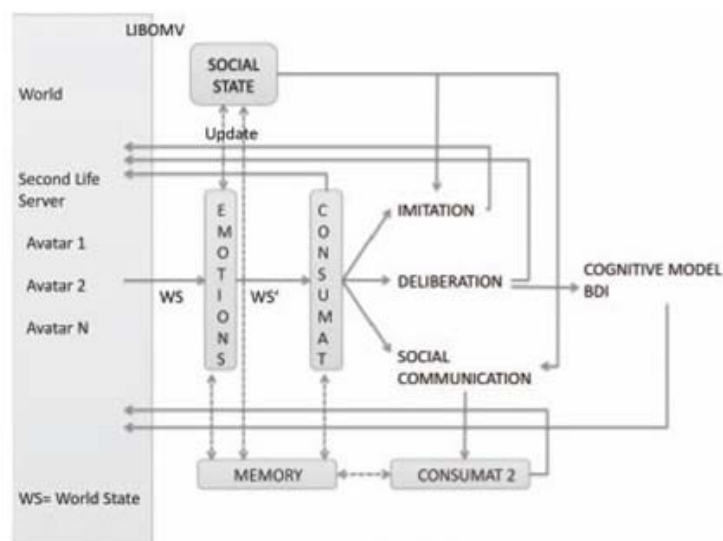


Figure 2.9 – Ontology example based on IVA (Van Oijen, Van Doesburg et al., 2011)

The BDI model has been extended with the addition of obligations to create the Belief Desire Obligations Intentions (BOID) models for representing norms in agent designs. One of the limitations of such models is the static/pre-programmed obligations that do not change over time as norms do. For creating believable agents the social game agent model was created as an extended BOID agent creation model (Figure 2.10) in which social states affect emotions but these change over time depending on both the current norms and the what happened in the past/what is stored in the memory of the agent. For making agent behaviour more believable, the model could be further extended by implementing a kind of Time to live (TTL) mechanism for these memories or rules that will dictate when they will degrade/forgotten (Johansson, Verhagen *et al.*, 2011)



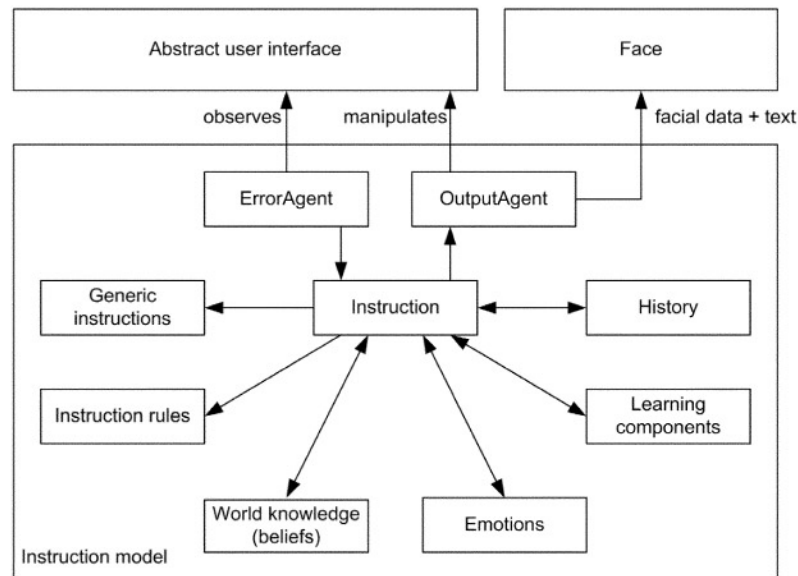


Figure 2.12 - The agents and components of the tutor element in INES

(Marin, Hunger et al. 2006) link emotions theory with agent design technology for motivating distance learners. According to the authors the design of the agents works well when using a combination of the following factors:

1. Emotion Theory's three branches:
 - a. Emotions arising from aspects of objects, for example liking and disliking
 - b. Emotions which are consequences of events
 - c. Emotions that are part of the attribution class: pride, admiration, shame and reproach
2. Personality: Traits that predispose people to act in a consistent way
3. Attitudes: These describe the relationship between tutor and student. They are: trust or don't trust, like or dislike

Another study was conducted using an inquiry-based virtual learning environment, CRYSTAL ISLAND, for researching the effect of virtual tutors' affect on school students in the domains of microbiology and genetics. Task-based feedback was implemented so that a summary of the student's progress was given by the tutor if the student was either progressing well or,

at least, was confident that he would achieve the goal by his own. On the other hand if the student reported a negative state of mind then the virtual tutor would intervene and try to assist the student in solving the problem (Robison, McQuiggan et al. 2009). Virtual agents should also incorporate into their design the following:

- They must show that they care about the students and their progress
- They must be sensitive to the students' emotions
- They should show enthusiasm about the subject they cover
- They must appear to have an interesting and rich personality

All of the characteristics above aimed to help the student enjoy the lesson more, have a more positive view of the learning experience and, consequentially, spend more time using the virtual learning environment.

Adapting to the student's skills, personal characteristics and knowledge is equally important when designing a virtual tutor. This allows the tutoring system to understand the individual student's behaviour and better manage emotional-driven behaviours. Figure 2.13 shows the design of such a system, the Intelligent Tutoring System (ITS) (De Antonio, Ramirez et al. 2005).

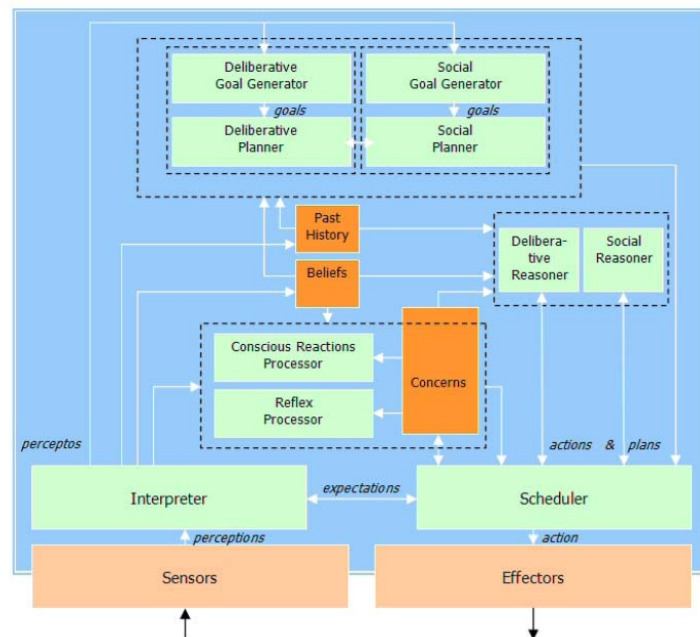


Figure 2.13 - Architecture for agents with behaviour influenced by personality and emotions

Another system that was designed for allowing the tutor to express emotions, in response to the students' actions, is AITS, an architecture for Affective Intelligent Tutoring Systems Figure 2.14. This model takes into consideration both the cognitive state and the affective state of the student. The emotional tutor (Emilie-1) – Figure 2.15 uses the information for generating emotions with a computational algorithm based on the OCC model.

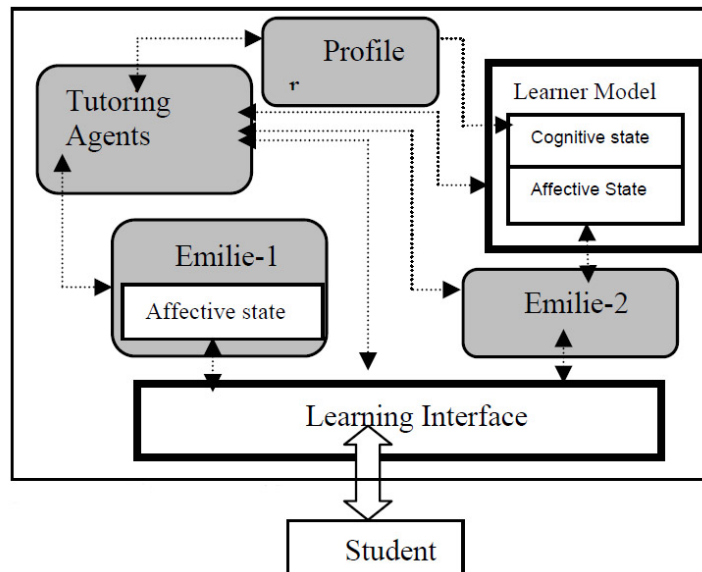


Figure 2.14 – Architecture of AITS

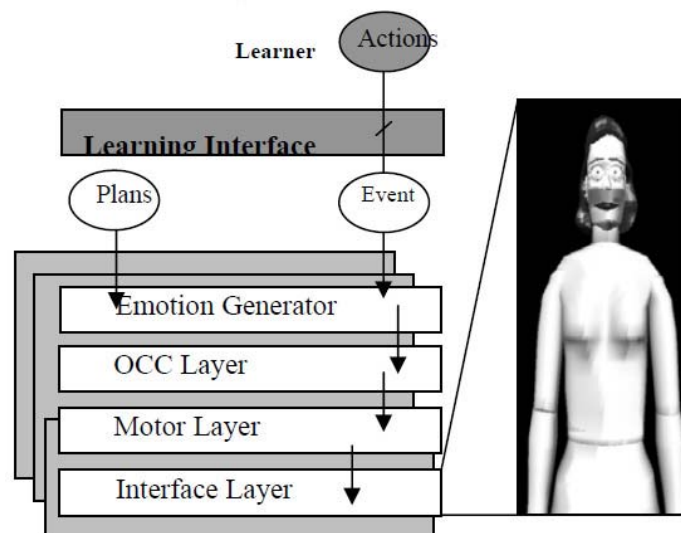


Figure 2.15 – The emotional tutor, Emilie-1

Virtual tutors need to be able to communicate their emotions to the students/trainees. This can be done by a variety of ways: text, animated text, emoticons, gestures, facial expressions or a combination of some or all of the above. Some of these options will be discussed in the following sections.

2.2.4 Previous work in the area of integrating emotions and personality into virtual training systems

The Virtual Puppet Theatre (VPT) project (Andre et. al. 2000) attempts to integrate personality and emotions into agents by using elements of the OCC and FFM models. The model was successfully implemented in a virtual world for young children where an avatar interacted with virtual animals. At the moment VPT is only using the dimensions of extroversion and agreeableness from FFM for modelling personality as these determine how agents react in social interactions. By adding more of the FFM dimensions e.g. neuroticism, VPT could be further modified for usage in stressful situations.

The Cognitive-behavioural architecture (Sandercock, Padgham et al. 2006) incorporates the notion of personality as a determining factor for the agent's future emotions and coping preferences. This approach enables improved character diversity and personality coherence across different situations. Initial results using a virtual world where children have conversations in school with someone they never met before were encouraging. A promising direction for this architecture would be to confirm if and how personalities are obtained and maintained through time using a longitudinal study and also test the architecture in more stressful environments.

Another study by Zoumpoulaki et al (2010) on emergency evacuations incorporates both emotions and personality into BDI but their focus is on crowd responses during evacuations and they do not deal on the individual emotional responses during learning.

A very recent study by Harley *et al.* (2016) also found significant relationships between certain emotions and personality traits for predicting the participant's emotions towards virtual agents. Emotions such as anger and anxiety were found to have a strong correlation with personality traits, high neuroticism or agreeableness, thus supporting that emotionally adaptive agent-based virtual environments can support learning.

2.2.5 Personality types

In addition to the user's emotions, the virtual agents in our framework adapt their actions and emotions based on the user's personality traits.

An individual's personality type can be derived using a number of tools, some of which are listed below. We looked at a number of different models and decided on which to choose based on which had a category that better correlated with how negative emotions affected the participant.

- **Myers Briggs Type Indicator:** This psychological profiling tool attempts to categorise personalities based on C.G.Jung's psychological types: Extraverted Sensation, Introverted Sensation, Extraverted Intuition, Introverted Intuition, Extraverted Thinking, Introverted Thinking, Extraverted Feeling, Introverted Feeling. A lot of research went into this tool's design and it has been used extensively. On the other hand it is expensive and training needed for using it.
- **Keirsey Temperament Sorter:** Is a 70 question personality instrument for discovering an individual's personality type and is based on Keirsey Temperament Theory. According to Keirsey there are four distinct temperaments: Artisans, Guardians, Rationals and Idealists. These are further subdivided as shown in the tables below. This is one of the most widely used instruments but it is also costly and focuses more on observable behaviour rather than on how individuals feel and think.

ARTISAN	GUARDIAN	RATIONAL	IDEALIST
Promoter (ESTP)	Supervisor (ESTJ)	Fieldmarshal (ENTJ)	Teacher (ENFJ)
Crafter (ISTP)	Inspector (ISTJ)	Mastermind (INTJ)	Counselor (INFJ)
Performer (ESFP)	Provider (ESFJ)	Inventor (ENTP)	Champion (ENFP)
Composer (ISFP)	Protector (ISFJ)	Architect (INTP)	Healer (INFP)

- **iPersonic Personality Type:** Also based on Carl Gustaf Jung's work, this test is based on four dimensions: The Energy Dimension: Extraversion versus Introversion; The Information Dimension: Sensing versus Intuition; The Decision Dimension: Thinking versus Feeling; The Action Dimension: Perceiving versus Judging. This tool is free to use, based on a well-regarded theory. On the other hand it is not as widely used by large organizations as some of the other instruments.

TECHNICAL TERMS	MEANING		TECHNICAL TERMS	MEANING
(E) Extroversion	Expressive	vs.	(I) Introversion	Attentive
(S) Sensing	Observant	vs.	(N) Intuiting	Introspective
(T) Thinking	Tough- Minded	vs.	(F) Feeling	Friendly
(J) Judging	Scheduled	vs.	(P) Perceiving	Probing

- **DISC Personality Types and Profiles:** This tool is based on the DISC theory by the psychologist William Marston and focuses on four psychological traits for shaping personality: Dominance, Inducement, Submission, and Compliance. There is a free online version on 3rd party websites but the official version is expensive. Many different versions available but there is barely any academic research based on them.

- **INSIGHT Inventory Personality Profile Test:** This instrument uses the following four traits: Influencing (Indirect or Direct) - How people express thoughts and opinions; Responding (Reserved or Outgoing) - How people approach and respond to others; Pacing (Urgent or Steady) - The speed at which people make decisions and take action; Organizing (Unstructured or Precise) - How people structure time and organize tasks. It is based on the Field Theory of Dr. Kurt Lewin, the Trait Theory of Gordon Allport and the Factor Analysis of Raymond Cattell. This tool has some availability of research data and a lower price than many of the other tools but there is still some cost involved for larger research projects and it is not as highly regarded as some of the other tools.
- **Personality Style Inventory:** Similar to Myers Briggs Type Indicator. Also using Jungian personality types: Introvert-Extrovert, Intuitive-Sensory, Thinking-Feeling, Judging-Perceiving. This tool is not very costly and has been used widely but it is complex to complete and the resulting profiles need to be explained by an expert.
- **Belbin – team roles:** Based on Belbin's nine team roles: Plant, Resource Investigator, Co-ordinator, Shaper, Monitor-Evaluator, Teamworker, Implementer, Completer-Finisher, Specialist. This tool provides support for team work but, on the other hand, results can be limiting and there is a lack of extensive research data.
- **Five-factor (Big 5) model:** The five-factor model organises personality using five basic dimensions: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experience. From these dimensions neuroticism is connected to negative affectivity, or nervousness, which is the disposition to experience aversive emotional states. This direct connection of neuroticism with negative emotions is the main reason the five-factor model was chosen for this study. How neuroticism is connected to this thesis and evidence from previous research is further discussed on page 52.

Personality Test	Advantages	Disadvantages
Myers Briggs Type Indicator	<ul style="list-style-type: none"> • Well designed • Used extensively 	<ul style="list-style-type: none"> • Expensive • Operators need to be trained for its use
Keirsey Temperament Sorter	<ul style="list-style-type: none"> • One of the most widely used instruments 	<ul style="list-style-type: none"> • Costly • Focuses more on observable behaviour rather than on how individuals feel and think
iPersonic Personality Type	<ul style="list-style-type: none"> • Free • Based on a well-regarded theory 	<ul style="list-style-type: none"> • Not as widely used by large organizations as some of the other instruments
DISC Personality Types and Profiles	<ul style="list-style-type: none"> • Free online versions of 3rd parties • Many different versions to choose from 	<ul style="list-style-type: none"> • Official version very expensive • Very little academic research is using this test
INSIGHT Inventory Personality Profile Test	<ul style="list-style-type: none"> • Some availability of research data • Comparatively low price 	<ul style="list-style-type: none"> • Not as highly regarded as some of the other tools
Personality Style Inventory	<ul style="list-style-type: none"> • Not very costly • Has been used widely 	<ul style="list-style-type: none"> • Complex to complete • Resulting profiles need to be explained by an expert
Belbin – team roles	<ul style="list-style-type: none"> • Provides support for teamwork 	<ul style="list-style-type: none"> • Results can be limiting • Lack of extensive research data
Five-factor (Big 5) model	<ul style="list-style-type: none"> • Free to use • Direct connection of neuroticism with negative emotions (positive for the scope of this study) • Extensively used 	<ul style="list-style-type: none"> • Limited scope - does not explain all of human personality

After the emotions of the virtual agent are derived using the enhanced BDI model they will need to be communicated to the user of the virtual training environment. In the following subsections we will discuss different ways this can be achieved.

2.2.6 Text based emotion communication

(Wang, Prendinger et al. 2004) designed a chat system using animated text that was associated with emotional information for displaying the affective state of the online user. This animated text, also referred to as kinetic typography, can change its shape and location for conveying emotion, affect and the speaker's tone of voice. According to their experimentation this animated text made it more likely for the users to become more involved in the conversation and more eager to talk more often and for longer. For building kinetic typography the designers can use either general purpose animation tools (i.e. Adobe After Effects or Macromedia Flash) or specific tools such as Apple LiveType, Wigglet, and ActiveText (Lee, Jun et al. 2006).

According to (Rashid, Aitken et al. 2006) the animation properties of standard kinetic text properties are as follows:

- text size
- horizontal and vertical position on the screen
- text opacity
- speed/rate of the animation
- duration of the animation and/or text appearance
- text vibration

Some of the emotions that can be inferred by kinetic typography are shown in Figure 2.16.

Emotion	Relevant Properties (Effect)	Intensity of Effect
Fear	<i>Size:</i> Repeated and rapid expansion and contraction of the animated text. <i>Rate:</i> Expansion and contraction occur at constant rate. <i>Vibration:</i> Constant throughout the effect.	<i>Low:</i> Size of animated text is the same as non-animated text at onset. Low level vibration. <i>High:</i> Size of animated text is larger than non-animated text at onset. High level of vibration.
Anger	<i>Size:</i> Abrupt expansion and contraction of the animated text (through one cycle). <i>Vibration:</i> Occurs at largest size in cycle. <i>Onset:</i> Fast onset <i>Duration:</i> Pause at largest size in cycle and vibration occurs here.	<i>Low:</i> Size of effect is smaller. Slower onset. <i>High:</i> Size of effect is larger. Faster onset.
Sad	<i>Size:</i> Vertical scale of text decreases <i>Position:</i> Downward vertical movement from baseline. <i>Opacity:</i> Decrease in opacity <i>Offset:</i> Slow offset.	<i>Low:</i> faster offset <i>High:</i> slower offset.
Happy	<i>Size:</i> Vertical scale of text increases <i>Position:</i> Upward vertical movement from below baseline. Follows a curve (fountain-like).	<i>Low:</i> Slower onset. Offset text size is smaller. <i>High:</i> Faster onset. Offset text size is larger.

Figure 2.16 – Summary of animation properties for some basic emotions (Rashid, Aitken et al. 2006)

2.2.7 Using facial expressions for communicating emotions

Ekman (Ekman 1979) classifies facial expressions into:

- Manipulators: fulfilling biological needs i.e. blinking
- Regulators: used for controlling dialogue i.e. signifying who's turn is to speak
- Conversational signals: emphasising words or sentences
- Punctuators: used during speech pauses
- Emblems: replacing speech
- Emotional emblems: communicating non-felt emotions
- Affective displays: communicating felt emotions

A list of important components of widely recognised facial expressions is outlined in Figure 2.17 (Smith and Scott 1997).

	Facial action						
	Eyebrow frown	Raise eyebrows	Raise upper eyelid	Raise lower eyelid	Lip corners	Open mouth	Raise upper lip
Muscular basis	corrugator supercilii	medial frontalis	levator palpebrae superioris	orbicularis oculi	<i>a</i>	orbicularis oris	levator labii superioris
Action Units	4	1	5	6,7		26,27	9,10
<i>Emotion expressed</i>							
Happiness				X	Raise	X	
Surprise		X	X			X	
Anger	X		X	X			
Disgust/contempt	X			X			
Fear	X	X	X			X	X
Sadness	X	X			Lower		

Figure 2.17 - Components of widely recognised facial expressions (Smith and Scott 1997)

Pelachaud and Poggi (Pelachaud and Poggi 2002) claimed that communicative functions of a believable embodied agent's facial expressions can be divided into five main groups and provide information on:

- location and properties of events and objects
- agent's beliefs
- agent's intentions
- agent's affective state
- metacognitive information on the agent's mental actions

Multiple emotions can be represented visually using facial expressions of a virtual agent by blending them using a model based on fuzzy logic. Ochs et al. created the embodied conversational agent Greta which was able to visually portrait combinations of emotions using both superposition (combining the upper and lower parts of two distinct expressions) and masking (the upper face shows the expression while the lower tries to mask it as usually the upper part of the face is more difficult to control). Figure 2.18 outlines the architecture for the intelligent expressions of emotions whereas Figure 2.19 shows a series of facial expressions demonstrating superposition and masking of Greta (Ochs, Niewiadomski et al. 2005).

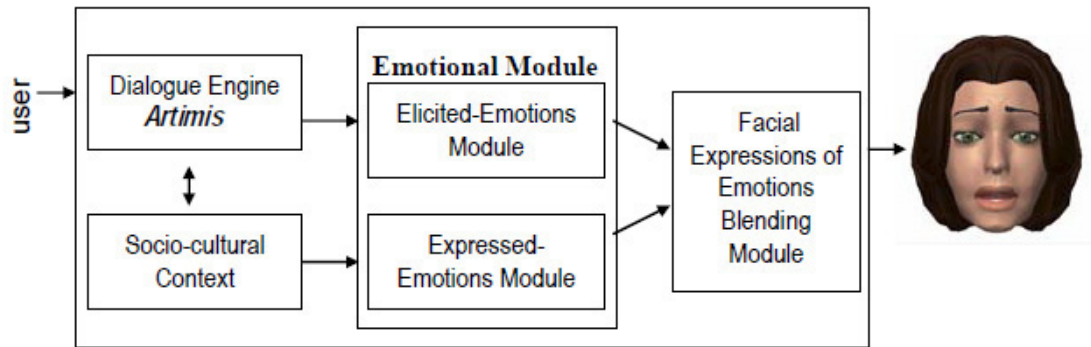


Figure 2.18 - Architecture for the intelligent expressions of emotions (Ochs, Niewiadomski et al. 2005)

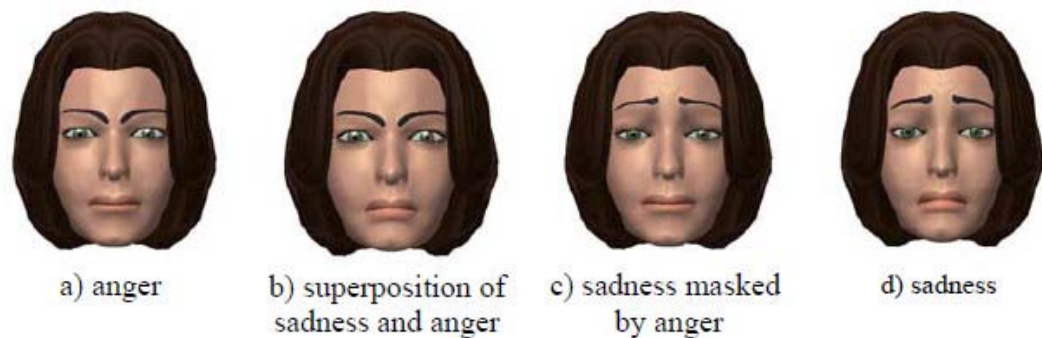


Figure 2.19 - Facial expressions of Greta (Ochs, Niewiadomski et al. 2005)

Using a set of universal emotions and the possible expressions that stem from them (Figure 2.20), Fitrianie and Rothkrantz created a model (Figure 2.21) for analysing text for emotions, mapping them to an XML database, mapping the emotions to a facial expression and generating an animation for displaying the emotion using a virtual face (Fitrianie and Rothkrantz 2006). The model could be further developed for including emotion analysis based on personality, moods and background context of dialogues.

Universal Emotions	Emotion Expressions
Happy	Inspired, desiring, loving, fascinated, amused, admiring, sociable, yearning, joyful, satisfied, softened.
Sad	Disappointed, contempt, jealous, dissatisfied, disturbed, flabbergasted, cynical, bored, sad, isolated, melancholic, sighing.
Surprise	Pleasantly surprise, amazed, astonished.
Disgust	Disgusted, greedy.
Anger	Irritated, indignant, hostile.
Fear	Unpleasantly surprised, frustrated, alarmed.
Neutral	Curious, avaricious, stimulated, concentrated, eager, awaiting, deferent.

Figure 2.20 - Universal emotions and possible expressions (Fitrianie and Rothkrantz 2006)

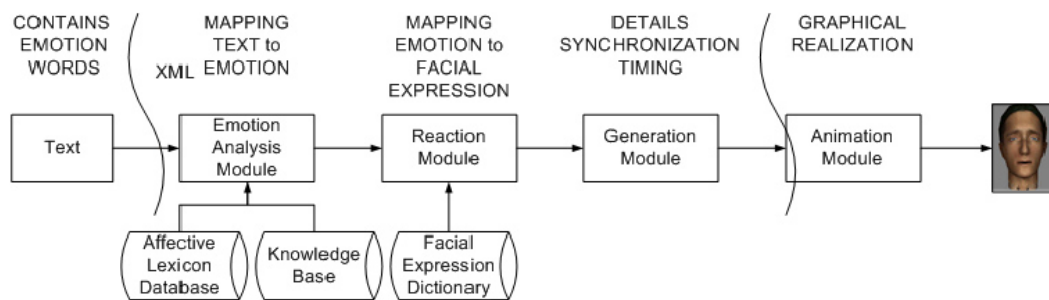


Figure 2.21 - System architecture (Fitrianie and Rothkrantz 2006)

A more recent study looked at the responses of students to the facial expressions of tutors in a virtual learning environment. The results of the study showed that the students would respond better, be more motivated and show higher enthusiasm when facially expressive virtual tutors were used. This led to better learning outcomes. Students preferred it when the virtual lecturer was happy but inappropriate use of smiling was thought to be insensitive and led to a decrease of student performance. The study could be further improved by the use of an animated body for a more accurate representation of the lecturer's emotions through the use of gestures (Theonas, Hobbs et al. 2008) .

2.2.8 Using sounds for communicating emotions

Vocal emotional signals are often used for sharing important information or warning humans of danger. According to research by Sauter *et al.* (2009) emotions that are referred to as 'basic', anger, disgust, fear, joy, sadness, and surprise, can recognised across cultures through the use of sounds.

The modelling of emotions unto virtual characters for tactical decision-making games was tested by Visschedijk *et al.* (2013). Twenty-eight adults participated in the study which used 30 animations of virtual characters. The characters had the ability to show their emotion using a facial expression, their voice and their posture. Different variants were created for a selection of emotions. These included posture (P), posture and voice (P+V), posture and facial expression (P+F) and posture, facial expression and voice (P+F+V). The variants without voice did not have any sound at all. The ability of the

user to recognise the emotion of the virtual character was tested with the following results. The P+F+V showed the best recognition rates with P+F and P+V being joint second best.

2.2.9 Using emoticons for communicating emotions

Emoticons are able to enhance text based communication by providing information on possible facial expressions of the users and allowing them to adapt the conversation based on social cues that would not be easily inferred by reading the verbal text of a message (Derks, Bos et al. 2008).

The first emoticon was used in 1982 by Prof Scott Fahlman Carnegie Mellon University. In one of his messages on the computer science bulletin board he proposed the usage of “:-)” and “:-(” for distinguishing jokes from serious matters (Research.microsoft.com, 2015).

Emoticons are so commonly used nowadays for expressing emotions both online and on mobile phone text messages that approaches of sentiment analysis that incorporate the study of emoticons are now being developed (Hogenboom et al., 2013)

Emoticons have been successfully used for graphically displaying emotions in a serious game about conflict resolution as an easy to understand way of marking the rating of an emotion in a Likert scale (i.e. highly positive, somewhat positive, neutral, somewhat negative, highly negative) as demonstrated by Cheong *et al.* (2015).

For this research, simple emoticons representing primary emotions were selected. These were chosen because they are easy to understand due to being commonly used by most people in social media and other, similar, applications i.e. Microsoft Messenger, Skype, Facebook etc. The emoticons chosen are mostly of negative emotions due the proposed usage, representing the emotional state of people with dementia, and the scenarios implemented within the virtual training system, which were illustrative of stressful situations where negative emotions were a likely outcome.

Animations such as the ones provided by software like PrEmo (<http://www.premotool.com/>) can also be used for similar effect but as animations of postures and facial expressions were already implemented within the 3D virtual character models; simple emoticons were more suitable for complementing these. The use of emoticons offers a more immediate understanding for the participants on what emotional state the virtual agent is in without any doubt on what they represent. None of the nine participants in this study had any ambiguity in relating the emoticons with the emotions these represented.

For the purpose of testing the prototype of the emotionally intelligent virtual agent we will be using a scenario where the user will have to care for a person with dementia. In the following section dementia and its effects on both the patient and the carer is introduced.

2.3 Dementia

Dementia is an umbrella term for a group of related progressive conditions that are linked with a decline in brain functioning. Individuals with dementia may exhibit a number of symptoms depending on the type and the severity of their condition. People living with dementia may not only find it hard to cope with the demands of daily living, but can also have difficulties making sense of and regulating their emotions. They may have symptoms of depression and also find it difficult to interpret and understand the emotional responses of others. According to statistics from the Alzheimer's Society the UK has an ageing population with growing numbers of people with dementia; research to support their emotional and physical well-being is needed (Alzheimers Society, 2015).

As a person's cognitive abilities decline they will need a great deal of support to cope with daily living. Support is often provided by people close to them such as friends and family. These informal and generally, although increasingly not always, unpaid carers provide reassurance, do things with them and facilitate a level of independence (Kraus et al., 2010).

Supporting someone with dementia, especially a family member, affects many aspects of a carer's life and can be both physically and mentally exhausting. However, positive feelings can include the satisfaction of reciprocating care, ensuring their loved one is getting the best care and a sense of spiritual and personal growth. A person with dementia depends on the carer not only for practical help and personal care but also for emotional support. Caring for a person with dementia often leads to feelings of loneliness, grief, anger and resentment (Shah et. al, 2010). The risk that a carer is significantly impacted by these feelings depends on factors such as their gender, age, the health of the caregiver, ethnicity and social support. Although some of the factors cannot be controlled, support provided to the carer can have a significant impact on reducing the carer's psychological distress. Such support includes respite, training and education programmes and information-technology based support (Etters et al. 2008, Carretero et al. 2009).

A systematic review of 12 studies investigated the effectiveness of dementia carer oriented interventions delivered through the internet (Boots et al.,2014). The review demonstrated that internet interventions can result in positive effects on the carer's wellbeing. More specifically multicomponent programmes that combine information, caregiving strategies, and contact with other carers have positive effects on their confidence, self-efficacy, stress reduction, and avoidance of depression.

In the following section ways of recording the user's emotions during the virtual scenarios are discussed.

2.4 Markup Languages

For the recording of the user's emotions and the corresponding responses of the virtual agent it has been decided that a markup language will be used for maximum interoperability. In this section a selection of commonly used markup languages is listed and compared for deciding on the most suitable one. This section was presented in an international conference and published in the conference's proceedings (Loizou *et al.*, 2012)

2.4.1 Background

According to Schröder (Schröder, Devillers et al. 2007) markup languages usually represent emotions as part of more complex scenarios, such as conversational agents, and often focus on only a small subset of the available emotions. Currently used markup languages are in need of a vital ingredient, namely the decomposition of emotions into basic components, so that they can account for the different ways people feel, and express these feelings, in different situations. A framework incorporating the markup language and its associated code should, ideally, be able to recognise and record emotions, correlate these with the associated feelings and output a range of expected behavioural patterns. These patterns should be individualised based on each person's previous experiences as these are bound to affect the number, range, and strength of the emotions and feelings, thus producing a behaviour that will differ in type, strength and duration.

2.4.2 Commonly used markup languages

A number of markup languages, such as APML (Affective Presentation Markup Language), MPML (multi-modal presentation markup language), CML (Character Markup Language), and BML (Behaviour Markup Language) were designed for recording and controlling the behaviour of computer controlled life-like characters. A few of these languages include some kind of emotion representation but do not have the capability to record emotions in the complexity needed by modern emotion research (Schröder, Pirker et al. 2011).

Pirker and Krenn (Pirker and Krenn 2002) compare a selection of markup languages (EML, VHML, CharToon, TVML and MPML) regarding the type and number of labels available for recording emotional states. TVML is the most restricted one, allowing only for two distinct states, 'Normal' and 'Excited'. The other four languages allow a larger variety of labels, with MPML offering a rather large number of tags: Admiration, Disappointment, Disliking, Fears-confirmed, Gloating, Gratification, Gratitude, Hope, Joy,

Liking, Pride, Relief, Remorse, Reproach, Resentment, Satisfaction, Shame, Sorry-for.

AIML (Artificial Intelligence Markup Language) is one of the first markup languages designed for creating natural language software agents. It is an XML dialect that includes recognition of set inputs and responses for recognising and responding accordingly to text input by the user. It is a simple way of creating simple bots (robotic agents) but cannot offer complex pattern matching for more advanced applications (Wallace 2003).

The Human Markup Language (HumanML) was an attempt in 2001 to create a markup language that would describe human characteristics that include, but are not limited to, thoughts, emotions and attitudes. Mood and emotions could be recorded and the information could be used for displaying the results of these emotions using body movement and gestures (Landrum and Ram 2003).

Multimodal Interaction Markup Language (MIML) was introduced by Xia Mao Zheng Li & Haiyan (Mao, Li et al. 2008) as a markup language specifically designed for allowing the description of emotions of lifelike agents when designing online intelligent interaction systems. MIML provides facial expressions and voice recognition tagging and, in addition to tag definition, also includes a compiler and an ActiveX controller module. The compiler validates the script for syntactical errors, uses SAX (Simple APIS for XML) for parsing and, finally, the converter module creates Vbscript code for online execution and user interaction.

Affective Presentation Markup language (APML) is a markup language designed for believable behaviour generation (De Carolis, Pelachaud et al. 2004). APML provides tags that describe the emotions of the agent and the type of the communication to be performed to display the state that relates to these emotions. One way this is achieved is by using a combination of facial displays (smile, frown, raised eyebrow etc.).

Some markup languages were designed for bridging the gap between recognising and recording emotions and displaying these emotions to the

user using animated characters (also referred to as avatars). Examples include VHML (Virtual Human Markup Language) and AML (Avatar Markup Language).

Emotion Markup Language (EmotionML) is a markup language designed from the ground up for the representation and processing of emotions and their related states and for providing a standard format that facilitates interoperability between different systems. EmotionML can be used with a number of emotion vocabularies for representing emotions and related states. Emotions are represented using scientific descriptors: categories (i.e. Ekman's "big six"), dimensions (i.e. Mehrabian's PAD dimensions), appraisals (i.e. Scherer's appraisals), and action tendencies (Frijda's action tendencies). EmotionML also allows users to define their own custom emotion vocabularies for complementing the existing ones (Schröder, Baggia et al. 2010).

2.4.3 The future

There are a number of options in dealing with the expanding needs of emotion oriented mark-up languages for the future:

a. Expansion/modification of currently available languages

A number of the markup languages currently available allow the user to either modify the original code and add variables and procedures to it or, alternatively, expand the number and/or categories of emotions that can be recorded. Advantages include possible support from the original author either in readily available tutorials or input to direct queries and the likelihood of having to spend less time on the modifications and troubleshooting/testing the final output. Disadvantages include a more limited number of possible modifications due to a lack of provision in the original code and/or restrictions to what the end user is allowed to modify or what he is allowed to use the resulting code for (i.e. for educational use only).

b. Merging/bridging two or more currently available languages

Some of the currently available languages can be combined using bridging scripts so that two or more markup languages are used together for increasing the scope of the individual components of each language. The advantage of this is a wider range of possible options that could be integrated into the final product. Disadvantages are more numerous and include difficulties in merging code from two different products, the likelihood of the authors of the original languages not agreeing in the terms of the integration, and more difficult and time consuming troubleshooting/testing of the final output.

c. Designing a new language from the ground up

Another option for addressing all of the requirements of a modern emotions oriented markup language is to design one from the ground up. This would offer the advantage of allowing the author(s) to integrate into the new markup language all of the options they deem to be necessary and would give them total freedom on its design and usage. On the other hand this would most likely be the most time consuming of the three options discussed here, requiring extensive research, design and troubleshooting/testing of the final output.

2.5 Summary

This chapter has served as an introduction to; the psychological basis for this research, the design of affective virtual agents, and on how online training can help carers of people with dementia reduces their psychological distress. It also introduced ways of recording, storing and retrieving emotion related data for online learning environments. The next chapter describes the design of the emotional virtual agent's experimental framework and prototype virtual learning environment.

3. Design of the Emotional Virtual Agent's Architecture for Virtual Patients in Interactive Training Software

This chapter presents an architecture for creating a virtual agent that alters its mood and behaviour depending on the, personality, emotions and responses of the human user. A high-level overview of the architecture design is presented in Section 3.1. The remainder of the chapter describes how the system is designed, how the Jboss DROOLS Expert rules engine is used for providing feedback to the user and how the BDI model has been adapted and used for providing emotional intelligence. The front end of the learning environment has been designed using the UNITY3D game development system and programmed using C# to communicate with the server back end. The researcher chose a 3D system rather than a 2D one in an effort to increase the visual realism of the scenario by representing the real world more closely and, also, to have the option in the future to enhance the system by allowing the use of augmented reality headsets such as Oculus Rift or Google Cardboard. The back end was programmed using JAVA and runs under Tomcat so that several front end sessions can communicate concurrently with the server. The BDI system architecture runs on the server and is extended using a custom DLL file created using Eclipse and the JBOSS rules engine. The rules written using JBOSS extend the BDI architecture to include the personality and emotions of trainees.

Open source software was, partly, used due to cost consideration and the ability to more easily get answers to common issues online when using popular tools and programming languages. Initially we started creating a version of the framework implementation using a demo (limited time) version of the JACK BDI agents software. This was later abandoned due to the high cost of purchasing the full version and also the possibility of not being supported in the future by the company that created the software. Open source code also provided more customisability and flexibility for both current project needs in addition to possible future changes/additional capabilities to be added.

3.1 Architecture design

This chapter presents an architecture for creating a virtual patient with the ability to alter its behaviour and mood based on the responses, emotions and personality of human users. Responses to human user actions are selected from a database of possible rules that are based on previous research and input from psychologists and experts in the area of health training. The experimental framework of adaptive tutor responses presented in this chapter is a general purpose architecture that can be applied to a variety of scenarios. The testing scenario used in this research focuses on training nurses to care for dementia patients. Example scenarios in this area include training a nurse on how to help patients who find it difficult to feed themselves, suffer from depression, or forget who they are and where they are.

A high-level overview of the architecture can be seen in Figure 3.1. The proposed architecture extends the Belief, Desire and Intention (BDI) model by incorporating the emotions and personality of the trainees in the decision making process. As discussed in the literature review emotions are not typically a part of the BDI model. The systems that have explored emotion integration, such as the BDI tutor model (Florea and Kalisz 2005) and Model Social Game Agent (MSGa) model (Johansson, Verhagen *et al.*, 2011) focus on just incorporating the emotions of trainees and do not take other factors into account, such as a trainees personality traits. The proposed architecture in this study focuses on individuals rather than groups and on both the emotions of human trainees and virtual agents. The emotional state of the trainees is not approximated by the framework but reported by them instead based on how they actually feel as the scenario progresses. This makes it more realistic and personalised as it focuses on the individual's emotional state and how this changes throughout the training session.

Personality affects the scale and duration of emotions thus the architecture proposed in this work extends the BDI model by incorporating two new elements into its design. Firstly, the proposed system incorporates the current emotional state of the user into its decision making process.

Emotions are inputted in real time, by the user from within the virtual training environment. Secondly, the system incorporates the personality of the user. This is determined using a personality profiling tool. The feedback provided to the user as well as the patient's emotional state is affected by both these elements. For example, a response by a user with a higher neuroticism score will affect the patients' emotional state to a greater degree as the user will be more likely to respond to the patient in a harsher tone. Similarly, the feedback towards a more neurotic user has to be firmer so that it is made clear that the user has to respond to the patient using a more sympathetic tone.

The scenario consists of a question that the patient asks and a number of possible answers the user can select from as a reply. One of the replies is the correct one which allows the user to proceed to the next question and the rest are incorrect. The incorrect ones will affect the emotions of the patient negatively.

Patient question: "Should I be here in this place?"

- Correct reply which does not affect negatively the emotions of the patient:
 - "I know you are worried about being here in hospital. Did you need to use the toilet?"
- Incorrect replies that affect the patient emotions in a negative way:
 - "I have told you before, but perhaps you have forgotten? You are in hospital."
 - "Please stop talking to me and interrupting me while I am trying to do the medicine round."
 - "You are in Hospital and you have to stay in for quite some time."

How much the negative replies will affect the emotions of the patient also depends on the negative emotions of the patient (which are, in turn, affected by their personality as explained later in this section).

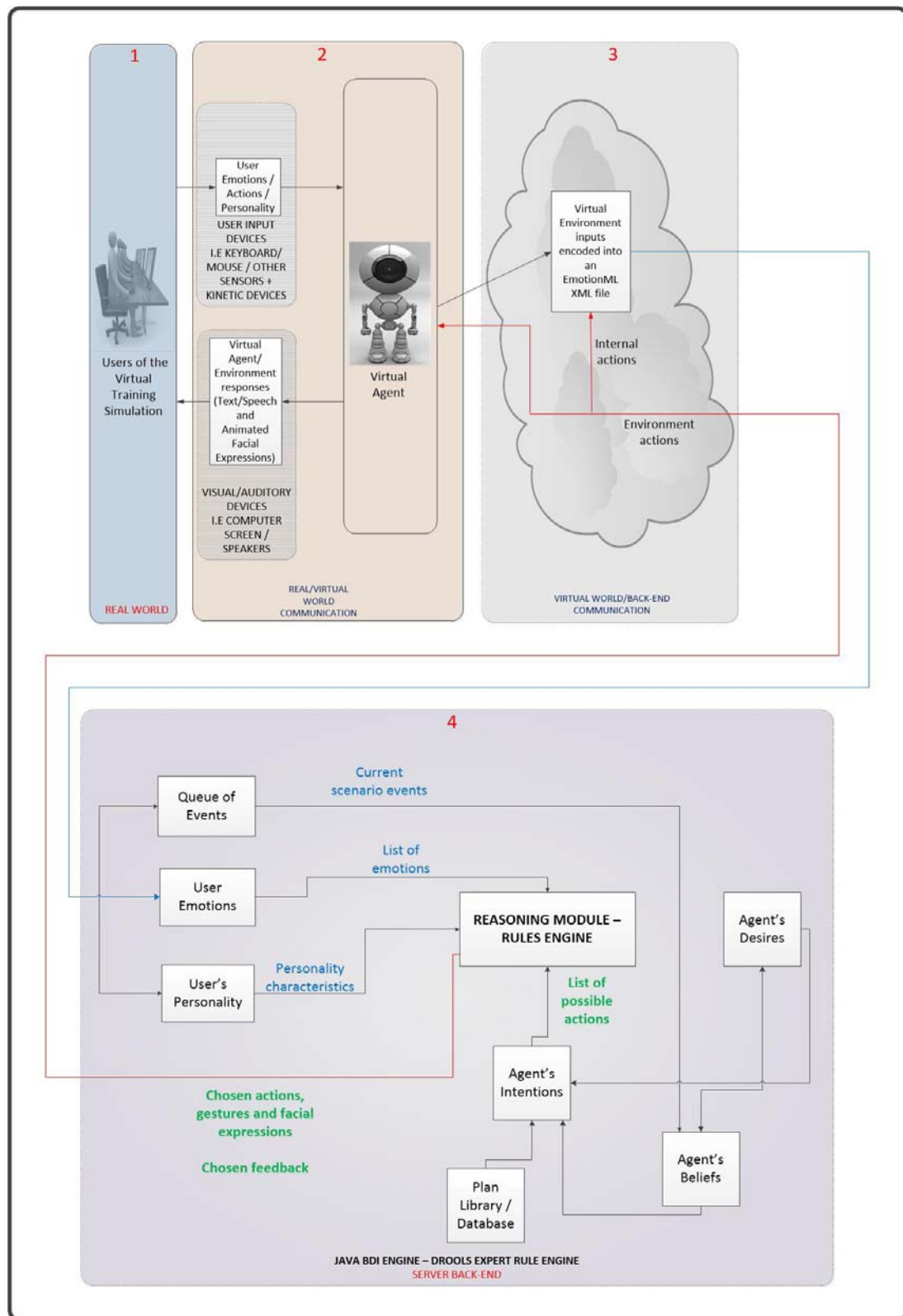


Figure 3.1: High-level overview of the proposed Emotional Virtual Agent's Architecture.

In the proposed architecture the agent's beliefs can affect decision making either directly or after taking into consideration the agent's personality and emotional state. These factors along with the agent's desires form its intentions which, themselves, are turned into actions. These actions can, again, be affected by the agent's emotional state before the agent selects one and more actions that can affect the environment, other agents, or both. The performed actions along with the current agent emotions will affect its perception of the environment and, in turn, alter its beliefs.

Section 1 of Figure 3.1 illustrates the real world and the users taking part in the virtual training simulation. Section 2 illustrates the communication between the user and the virtual agent. Section 3 illustrates the data communication between the virtual training environment and the emotional agent architecture on the server. Finally, Section 4 illustrates the decision making process based on the BDI system, available plans, user emotions and personality. Once inputted, the events, emotions and personality characteristics of the user are sent from the virtual learning environment to the server, as shown in section 3 of Figure 3.1.

The interaction between the user and the proposed architecture, via the virtual tutor, is shown in sections 1 and 2 of Figure 3.1. The users take part in a training scenario within a virtual world designed using a game engine. The communication between the user and the virtual tutor is achieved through the use of dialog boxes. Input devices, such as the keyboard and mouse, allow the users to move their avatar within the virtual hospital and select their choice of action using selection boxes. Users input their personality type and their current emotional status by selecting the type and intensity of their emotions, using selection grids as shown in figures 3.2 and 3.3. This method of emotional input was used as it is a quick and reliable way for collecting information on the emotional status of a trainee in a real time environment. This approach, using a graphical user interface (GUI) widgets to collect and represent emotions on the screen, has been tested and guidelines were derived from a set of preliminary studies (Cernea et al., 2013). Based on these guidelines the visual emotion representation in our system will clearly

reflect the various dimension of the user's emotional attributes but will avoid displaying more than one emotion at any given time to avoid overwhelming the user with too much information that might distract him/her from the task in hand.

Section 4 of Figure 3.1 illustrates the main part of the emotionally responsive virtual agent system. The server contains a virtual tutor that is responsible for interpreting the inputs from the virtual training environment and returning a set of actions, in the form of text feedback, to be communicated to the user. The module also returns a set of gestures and facial expressions to be used by the virtual tutor's 3D model as well as a sound clip. The virtual tutor adapts its responses to user and scenario events thus enhancing user learning by providing responses that are tailored to the user's current emotional state and personality. The emotion scale is adapted based on the user's neuroticism score (i.e. based on psychological research, users that are more neurotic tend to overstate their stress and anger self-reporting so their emotion scale is adjusted downwards to compensate for this). The adjusted emotion scores are then used to select a different feedback for the user.

The main component of Figure 3.1 Section 4 is the reasoning module of the architecture. This module uses the Jboss DROOLS Expert rules engine (Drools.org, 2015) for selecting the tutor's feedback from a database of possible responses. This is explained in more detail in section 3.2. A set of rules adapts the responses based on the trainee's emotions, emotion strength, and personality traits.



Figure 3.2 - A screenshot of the virtual enviroment generated by the Unity 3D game engine. In this screenshot the user is inputting their emotional scale and is communicating with the tutor

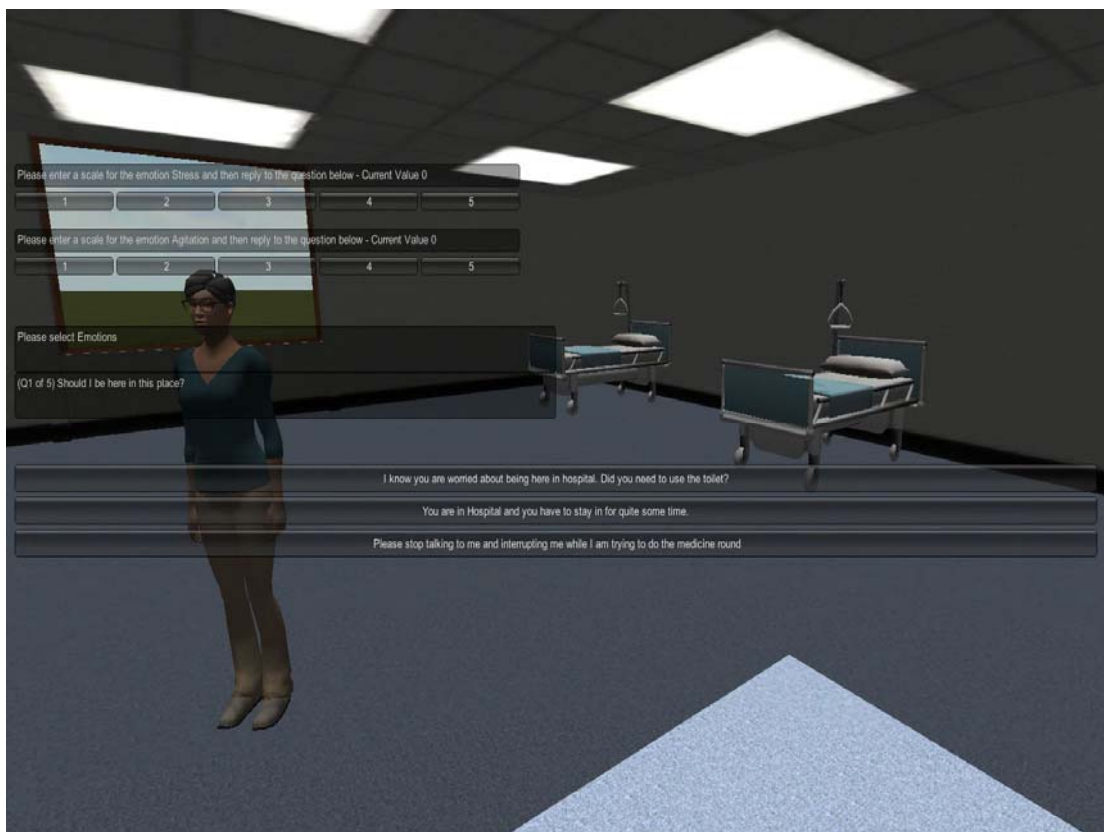


Figure 3.3 - A screenshot of the virtual environment generated by the Unity 3D game engine. In this screenshot the user is inputting their emotional scale and is communicating with the virtual patient

According to Ng and Diener (2009). Individuals high in neuroticism felt more negative and experienced less decrease of their negative emotions than individuals low in Neuroticism (low N) when extremely unpleasant hypothetical scenarios improved.

There is a significant positive total effect between neuroticism and perceived stress score. A review by Ebstrup *et. al* (2011) concludes that neuroticism predicts tendencies to appraise events as highly threatening and coping resources as low.

Pilot testing of the emotionally enhanced scenario using a group of 20 students (none of which were participants at the final study) regarding the level of neuroticism compared to the level of reported stress-anger (scale 1-10) showed an over or under reporting of an average of 1 point between different classifications of the neuroticism score/level (Very low / Low / Average / High / Very high). This was automatically compensated for.

For example, in the code illustrated below a user reports his 'Neuroticism level', based on the questionnaire completed previously, to be 'Very High'. This makes them more likely to overstate their negative emotions when rating them on a scale, thus, our algorithm needs to adjust this by decreasing the user's stated value, as shown in Figure 3.4. The reported emotion scale is, thus, adapted and decreased by 2 (Very high neuroticism is 2 levels above average so a decrease of 1 point per level).

```
rule "personality='VeryHighNeuroticism'"
dialect "mvel"
no-loop true
when
requestResponse
EVAVirtualHospital.RequestResponse(personality=="VeryHighNeuroticism")
:
then
requestResponse.setEmotionScale(requestResponse.getEmotionScale() - 2);
```

```

update(requestResponse);

end

```

Figure 3.4 – Algorithm for adjusting the self-reporting of emotions based on the user's personality

To further improve the realism of the scenario, random events ask for the attention of the carer, in a similar way to real world distractions. This adds to the realism of the scenario, which the participants confirmed during the interviews. Below is a sample of the code used in Unity3D for assigning the events into variables. These are then called in random and at random times by the game code (Figure 3.5).

```

Global.randomEvents[0] = "The bay phone is ringing, it may be an emergency. Please click here to answer it!";

Global.randomEvents[1] = "Mrs Jones in ward 4 is calling. Please click here to ask another nurse to help her!";

Global.randomEvents[2] = "Mr Ali is shouting again. Please click here to talk to him and help him calm down!";

Global.randomEvents[3] = "Mrs Cheng is calling, saying that she is hungry. Please click here to give her an apple!";

Global.randomEvents[4] = "Mr Romanof is calling, saying that he is thirsty. Please click here to give him some water!";

Global.randomEvents[5] = "Mrs Roads needs to go to the toilet. Please click here to ask another nurse to help her!";

Global.randomEvents[6] = "The patients complain that it is too hot. Please click here to open a window!";

Global.randomEvents[7] = "The patients complain that it is too cold. Please click here to turn the heating up!";

Global.randomEvents[8] = "Your supervisor is paging you. Please click here to check what he needs!";

Global.randomEvents[9] = "Your mobile phone is ringing. Please click here to put it on silent!";

```

Figure 3.5 – Algorithm for creating random world events, in accordance to the BDI model

The Drools engine outputs the feedback to be given to the user, and information that identifies how the user's response affected the emotional state of the patient. This information is then used to adjust the virtual patient's behaviour and animations. For example, an animation played and an emoticon can be displayed that show the patient's resulting emotional state. This approach allows the system to decide which actions will be performed by the virtual agent and what types of gestures, facial expressions and emoticons will be used for interacting with the user within the virtual training environment

In a similar manner, depending on the patient feedback, which is directly related to the emotion felt by the patient, an emoticon is displayed on the screen that shows clearly how the patient feels. The possible emotions portrayed are happiness, sadness, disgust, fear and anger, illustrated in figures 3.6, 3.7, 3.8, 3.9 and 3.10.



Figure 3.6 - Use of animations, sounds and emoticons for portraying the emotion of happiness for the virtual patient



Figure 3.7 - Use of animations, sounds and emoticons for portraying the emotion of sadness for the virtual patient



Figure 3.8 - Use of animations, sounds and emoticons for portraying the emotion of disgust for the virtual patient



Figure 3.9 - Use of animations, sounds and emoticons for portraying the emotion of fear for the virtual patient



Figure 3.10 - Use of animations, sounds and emoticons for portraying the emotion of anger for the virtual patient

The effect that the emotions and personality will have on the decision process is based on a set of threshold values. These are calculated using previous research on the impact of neuroticism on negative emotions and input by experienced psychologists and other experts from the field of

healthcare provision on how personality affects emotions during training (Williams, 1990).

The agent's beliefs are created and updated based on the agent's desires and current scenario events. The tutor uses dialogue boxes for training the user and prompting him/her to perform different actions. The user responds by performing the required actions and replies to the tutor using multiple choice and true/false responses.

The server decision making process consists of the following main modules:

1. **Agent's Beliefs:** Accepts as inputs events from the current scenario and the agent's desires. Based on these the module outputs a list of the agent's beliefs to the agent's desires and intentions modules. For example, a scenario input could be a patient that needs help finishing his meal and the tutor's desire to provide the needed help to the patient. The outputs of the module would include the intention to ask a nurse to help the patient and the desire to follow through by confirming at a later time that the nurse fulfilled her task.
2. **Agent's Desires:** Accepts as input a list of the agent's beliefs and outputs a list of the agent's desires to both the agent's beliefs and agent's intentions modules. Based on the example illustrated above, the module could receive the desire of the tutor to confirm that the nurse helped the patient finish his meal. The module would then output the intention of asking the nurse at a later time if she fulfilled the task of helping the patient and if the patient did, indeed, manage to finish his meal.
3. **Agent's Intentions:** Accepts as inputs a list of possible plans, the agent's desires and the agent's beliefs. It outputs a list of possible actions to the reasoning module. For example, inputs could include the plan of the tutor to ask the nurse to help the patient finish his meal by helping him sit at the table and cut the meat in manageable pieces, the desire of the tutor to help the patient and the belief that the patient needs the nurse's help for finishing his meal.

4. **Reasoning Module:** Accepts as inputs a list of possible user responses to the tutor's question and the user's emotions and personality traits. It outputs the chosen actions to be communicated to the user and a set of gestures and facial expressions to be used by the tutor's 3D avatar. For example, if the nurse is tired and not very empathetic then the tutor would ask her in a more firm way to help the patient. The tutor would be less firm when communicating with a rested nurse that is more likely to feel empathy for the patient that has difficulty finishing his lunch.

The remainder of this chapter is split into the following sections: Section 3.2 describes how the Belief, Desire and Intention (BDI) model is used in the architecture. Section 3.3 outlines the rules engine that forms the reasoning module. Section 3.4 defines the emotional elements and personality variables for the agent design.

3.2 Beliefs, Desires, and Intentions Model

A model for agent decision-making in interactive virtual environments is needed because agents are part of an environment that has limited resources, such as memory and computational power. This means that agents cannot take an infinite amount of time to process their next move(s). The BDI model was chosen as it is based on a sound psychological theory, Michael Bratman's theory of human practical reasoning (Bratman, 1988), and has been used in research extensively and successfully for a number of years. This model uses a set of rules that are designed to reduce the number of possible actions the agent can perform, thus reducing the time needed for the agent to decide which action to execute next. The environment within which the agents act changes continuously so the agent must decide upon its next move and act upon it quickly enough so that it ensures that the environment does not change in such a way that it may invalidate the selected action. BDI constrains the reasoning needed by the agent and, in consequence, the time needed for making a decision.

The personality component models the user's traits that affect how the scale of the reported negative emotions has to be adjusted before they are used by the rules engine for deciding on which feedback the tutor will return to the nurse. For example a nurse with a personality that exhibits a high level of neuroticism will report a negative emotion at a great scale than a nurse with a low level of neuroticism. In this case the rules engine will first lower the level of the emotion on the scale to match what a nurse with an average level of neuroticism would report before using the emotion type and level for deciding on which feedback to give.

For the implementation of the experimental framework a custom JAVA-based backend communicates with both the online learning environment, created using UNITY 3D games engine (Unity3d.com, 2015), and the Jboss DROOLS Expert Rules Engine. The use of the rules engine is discussed in the next section.

3.3 The reasoning module – Rules Engine

The rules engine is responsible for deciding which actions will be performed by the agent. This component of the architecture is implemented using the Jboss DROOLS Expert Rules Engine. Figure 3.11 shows a high-level overview of the production rule system used by JBOSS. The DROOLS Expert Rules Engine consists of three components; ontology, rules and data. Rules are a very important part of DROOLS and it uses pattern matching for comparing and finding similarities between new facts and production rules stored in the database. Based on this matching the Inference Engine decides on the action to be taken next. An example of a rule was demonstrated earlier in figure 3.5.

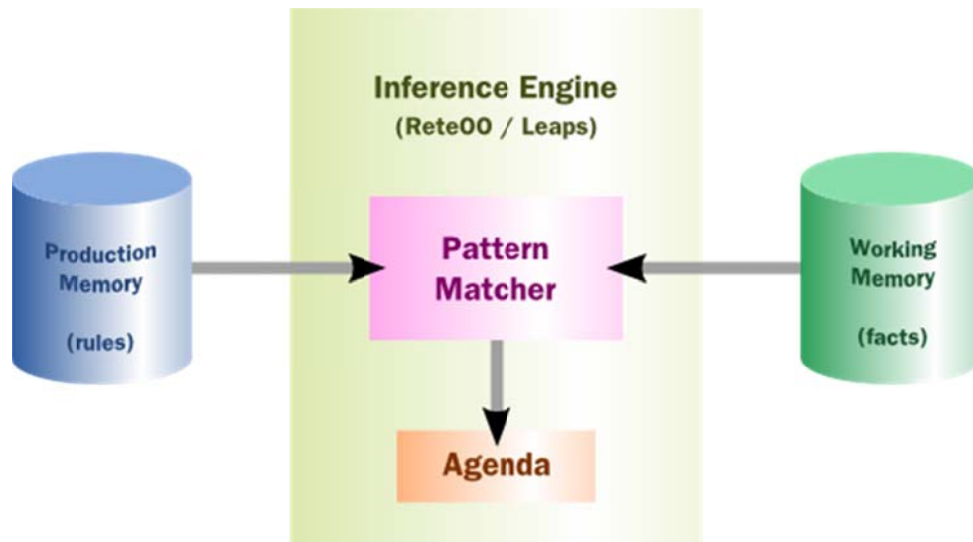


Figure 3.11 - An overview of the rules system used by JBOSS (<http://www.jboss.org>)

In Figure 3.12 we illustrate our own customised version of the rule system. In our design additional inputs are used by the Inference Engine for deriving the tutor's responses to the user and the animations/emoticons to be displayed. These inputs are the user's emotions and personality and the agent's desires, beliefs and intentions. The agent's desires, intentions and beliefs are interpreted by the BDI system in the production memory and are combined with the current scenario events and the user's emotions and personality from the working memory for deciding which plans will be returned to the virtual training environment for execution.

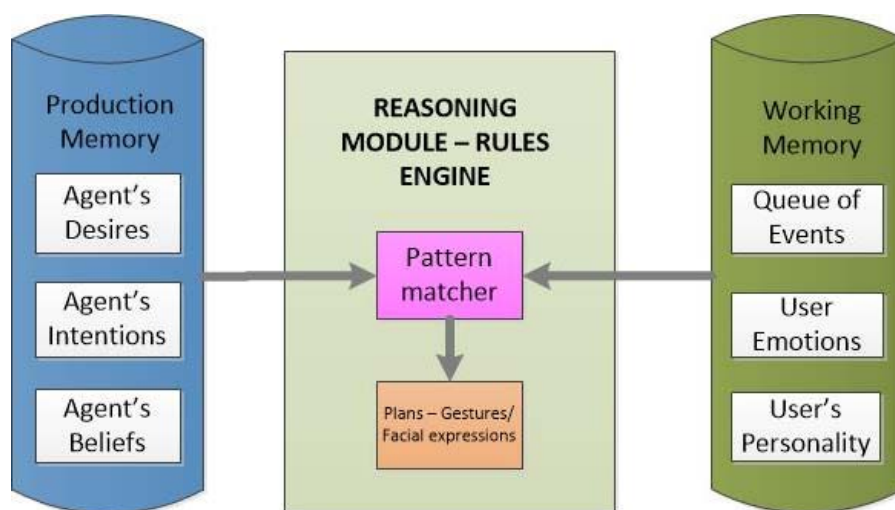


Figure 3.12 - The Inputs to the Rule System as customised for our design

DROOLS incorporates an inference engine that infers, or derives, new information from previous knowledge. In our framework the inference engine accepts inputs from working memory, current data coming from the virtual environment, (i.e. a queue of current events and user emotions) and production memory, data saved in XML files, (i.e. the user's personality characteristics which are derived from a personality test). The inference engine uses these inputs for deciding on the agent's plan of actions for reaching the desired goals for the current scenario. A selection of possible actions is inputted into the rules engine and the appropriate action to be executed is selected based on a series of rules. These rules take into consideration the user's emotions and personality and are designed based on input by psychologists. The users are made aware that both their actions and their emotions.

3.4 Emotional Intelligence for Virtual Agent Design

User emotions in the proposed architecture are inputted by the user using a keyboard and a mouse within the virtual learning environment (VLE). We decided to use commonly used devices such as a mouse and keyboard due to the familiarity of most users in operating these. This could negate additional stress of using something new to some of the participants. Increased familiarity with the interaction device meets usability goals of speed, comfort and accuracy (Dukes *et al.*, 2013) In the future we could recreate part of the study using cameras to record and identify emotional states and compare the results to the manual input of user emotions.

The user inputs are then transferred over TCP to the server/back-end to be interpreted by the DROOLS inference engine. The users input their emotions and preferred actions by replying to multiple choice questions, selecting one or more emotions and their intensity (using a Likert scale), and guiding their avatar through the 3-Dimensional environment while following the virtual tutor's instructions towards fulfilling the current scenario's goals.

The user's personality and emotions and the virtual agent's desires, intentions and beliefs are the inputs to the emotion creation and revision module. Emotions affect the best possible way an agent can respond to his requests. Personality affects the intensity and duration of these emotions. For example, using the Myers Briggs Personality Types, a Facilitator Caretaker incorporating the following Myers-Briggs Personality Preferences: Extraversion / Sensing / Feeling / Judging, is more likely to feel compassion and sadness for a patient than a Conceptualizer Director that incorporates the following preferences: Introversion / Intuition / Thinking / Judging.

In section 2.2 it was described how the strength of a user's emotions can be augmented or diminished due to personality characteristics. Thus virtual agents in our framework predict how to respond to the user's emotions depending on the user's personality. For determining the user's personality a number of personality profiling tools have been compared in order to choose the one most suitable for this research. For the purposes of this research the Five Factor Model (also known as the "Big 5") personality test (McCrae, 1998) was chosen for measuring the user's level of neuroticism. This has been proven to be related to the level that negative emotions affect an individual during training (Gallagher, 1990). In Appendix 1 you can see the paper version of the test that includes the formula used for each personality aspect. The paper version can be used when a meeting can be arranged with the participants or, alternatively, one of the many freely available digital versions online can be chosen.

The user's neuroticism level is then used to adjust the scale grade of the reported emotion. This is done using rules from the DROOLS engine. As people with higher levels of neuroticism tend to over-report their negative emotions, the rule is to decrease the level of emotion reported from users with higher than average levels of neuroticism and lower the reported level for users with lower than average levels of neuroticism. The reported emotion value will not be affected for users with average levels of neuroticism. Based on the adjusted emotion level different feedback will be given for different individuals. Figure 3.13 illustrates some of this code.

```

rule "personality='VeryHighNeuroticism'"
    dialect "mvel"
    no-loop
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(personality=="VeryHighNeuroticism")
    then
        requestResponse.setEmotionScale(requestResponse.getEmotionScale() -
2);
    end
rule "Q1-A1-T1-Stress<=3"
    dialect "mvel"
    when
        requestResponse : EVAVirtualHospital.RequestResponse(questionId ==
"Q1", answerId == "Q1A1", answerTextId == "Q1A1T1", emotion == "Stress",
emotionScale <= 3 && emotion="Anger" && emotion2Scale<=3)
    then
        requestResponse.setCorrect(Boolean.TRUE);
        requestResponse.setFeedback("Q1A1T1F1");
    end
end

```

Figure 3.13 – Algorithm for adjusting the responses of the virtual agent depending on the participant's personality traits and emotions

3.5 Summary

In this chapter we discussed the design of the emotional virtual architecture, described the BDI model and the reasoning engine used and explained how these were modified for the purpose of this research. We explained how the emotions and personality of the user were derived and how these affected the virtual agent's mood and the feedback provided to the trainee. In the following chapter the methodology for this thesis will be presented. The research design, data collection and manipulation, contributions to the field, ethical considerations and limitations of this study will also be discussed.

4. Methodology

This chapter presents the research design of this study, focusing on participants, data collection, validity, reliability, ethical considerations, and data analysis. This chapter has been submitted for publication in a peer-reviewed journal.

4.1 Research Design

The personality tool and emotions and how these affect the mood of the virtual patient were chosen and incorporated into the system based on proven psychological principles and meetings with psychologists that are experts in this field.

Two psychologists were consulted, chosen based on their qualifications (registered health psychologists) but also on their experience specifically working with people in the early stages of dementia and their carers. Their input on how negative emotions can affect the relationship between the carers and the people with dementia was integrated into the feedback provided by the virtual tutor to the human users of the virtual learning environment. The psychologists also confirmed the connection between neuroticism and negative emotions and agreed on the usage of this correlation in this thesis.

The chosen scenario for the data collection (Please see APPENDIX 5 for sample scenario questions, answers and feedback) was designed by a team of nursing tutors that specialise in the area of mental health and, specifically, in treating patients with dementia.

The virtual learning scenario run on a laptop connected to a 24" monitor, a set of speakers, a keyboard and a mouse. The system needed to run the scenario is quite modest, the minimum system requirements for running games developed with Unity3D are adequate for running the two scenarios:

OS: Windows XP SP2+, Mac OS X 10.8+, Ubuntu 12.04+, SteamOS+

Graphics card: DX9 (shader model 2.0) capabilities; generally everything made since 2004 should work.

CPU: SSE2 instruction set support.

A video demonstrating the virtual reality system can be found on both this URL (<http://tinyurl.com/Emotional-Agents>) and on the CD-ROM attached to the thesis.

The participants for the case studies consisted of nine nursing students with a particular interest in the area of mental health. All students were members of the same cohort at a UK university. The data collection process was as follows:

1. The researcher conducted an interview gathering background information about the participant (please see APPENDIX 3, Part-1). This information was useful in identifying trends that could, potentially, affect the participant's replies such as previous experience in using similar systems and a positive or negative predisposition in using such a system.
2. An online personality test (please see APPENDIX 2 for the paper version, the questions and the calculations for determining the personality trends were exactly the same for the online iteration of the test). This was used to determine the level of neuroticism of the participants
3. An online training session (SCENARIO_1) using a system that did not include different mood states for the virtual patient. The feedback given to the participants did not depend on their emotions and personality and the patient did not demonstrate any visual or auditory change in their mood. This session was delivered as a point of reference to the participant on how systems that do not cater for different personalities and emotions work
4. An online training session (SCENARIO_2) using an updated system based on the experimental framework designed for this research; the

second scenario provided visual (emoticons and animations) and auditory feedback on the patient's emotional state. The patient's emotional state and the feedback were affected by the trainee's emotions, personality and responses to the patient's questions

5. An interview for gathering data on how the training session potentially affected the learning process, emotional states and general satisfaction of the trainees (please see APPENDIX 3, Part-2)

As the sample size was not very large we did not want to add another variable to the equation so the order of the scenarios was randomly chosen (standard one first and emotionally enhanced as second) and kept it the same for all participants. We do not anticipate it would have made any difference to the results if the order was switched as the participants made it very clear that they found the modified scenario to be very much improved. Both scenarios were used on the same day and did not last long (on average ten minutes per scenario) so the participants had a clear recollection of both scenarios at the time of the interview.

A set of qualitative data was collected using observation and semi-structured interviews. The data was used to draw out patterns on how visual and auditory representations of a virtual patient's mood may affect the learning process, emotional states and general satisfaction of the trainees. The coding and data analysis can be found in Chapter 5. A sample log of the virtual training is included in Appendix

The Ethical Approval form can be found in APPENDIX 1 and the Participant information statement and consent form in APPENDIX 4.

4.2 Data Collection and manipulation

In this research two different types of methods were used as part of the data collection:

- Subjective: Self-reporting, using interviews, for measuring the believability of the VAs responses and the perceived satisfaction of the participants from using each of the two systems; Interviews were

chosen as they can provide the researcher with a detailed analysis of the participant's own perspective. Interviewing is a process through which the researcher attempts to find out what people have experienced, think or feel about certain things. According to Fraenkel there are four different types of interviews: structured, semi-structured, informal, and retrospective (Fraenkel, Wallen et al. 2006). In this research semi-structured interviews were used for gathering information from the participants. This type of interview is quite formal and is often used to collect information that can be compared and contrasted. Interviews also allowed the interviewer to ask follow up questions to clarify what the respondent meant and also gave the opportunity to the participants to ask for clarifications and even ask the interviewer their own questions. On the other hand interviews also have potential validity concerns, such as the interviewee responding in a way they feel it would please the interviewer. To counter this we also included data collected through observation.

- Objective: Observation of the participants going through the virtual learning scenario and recording their comments, expressions and overall experience. Data collected through this method were used to check that the participant's subjective replies were in line with what they did and how they behaved during the online training session.

In this thesis the following data were collected from the methods described above:

- Qualitative data from the semi-structures interviews conducted before and after the participants took part in the virtual training scenarios. The data were split into different themes, each one addressing one of the four research objectives (RO3 to RO6). The researcher analysed the replies of the participants and marked which data supported each objective and why. These are summarised in table format in section 5.1 and analysed in detail in section 5.2.
- The researcher also observed the participants while going through the virtual training scenarios. Any vocal exclamations, comments and

facial expressions that could be related to their experience were noted. For example one participant was so immersed emotionally in the experience that during the second virtual scenario she said loudly and excitingly “I am happy if you (the patient) are happy!”, when the virtual patient displayed a positive emotion.

In addition to the above, automated logs were created by the virtual learning environment while the participants completed the scenario (Please see Appendix 6 for a sample log).

Thematic Analysis

Thematic analysis was used for the analysis of this data. According to Guest et al.(2011) “Thematic analyses move beyond counting explicit words or phrases and focus on identifying and describing both implicit and explicit ideas within the data, that is, themes. Codes are then typically developed to represent the identified themes and applied or linked to raw data as summary markers for later analysis”.

4.3 *Ethical Issues and Study Limitations*

4.3.1 Ethical considerations

Marshall (Scott and Marshall 1998) defines ethics as: ‘the concern with what ought to be, whereas science (including social science) is concerned with describing reality as it actually exists’.

This study fulfils the following ethical guidelines:

- The participants provided their voluntary and informed consent prior to taking part in this research by signing a consent form;
- Participants were informed of their right to withdraw from the research for any or no reason, and at any time;
- There are no known risks of detriment arising from this research;

- Confidentiality and anonymity of the participants is assured as only the researcher is aware of their personal information and this will not be disclosed to any external party;
- The research complies with the legal requirements in relation to the storage and use of personal data as set down by the Data Protection Act (1988) and any subsequent similar acts. The data collected from this study are only accessible by the researcher and are securely stored in electronic form at the University of Wolverhampton network for 12 months after the completion of the research.

4.3.2 Design limitations

When using qualitative research it is possible to generalise, but when doing so, the researcher has to issue cautions regarding the limited capacity to do so due to limited numbers (Benz and Newman, 1998). This is a small scale study and, although a large amount of data was collected from each participant, due to the small sample size the results of this study are only generalizable within these limitations. On the other hand, as this is an exploratory study, the results will be useful for future researchers in conducting studies whose results will apply to a broader part of the healthcare provision population (Yin, 2013).

4.4 Summary

This chapter discussed the research design for testing the prototype for emotionally intelligent virtual agents, what type of data were data were collected and how and the way these were manipulated. Finally ethical considerations were discussed and study limitations were listed. In the following chapter the evaluation and analysis of the data will be described.

5. Evaluation

This chapter presents and interprets the results from the experimentation and evaluation of the developed emotional virtual agent's architecture. For the purpose of investigating if the data collected from the interviews and observation supported the following research objectives, thematic analysis was used for analysing the qualitative data. This chapter was submitted for publication in a peer-reviewed journal.

Themes were coded based on the following research objectives, as outlined in the tables below.

To satisfy RO3 - investigate if a virtual learning scenario incorporating emotional virtual agents provides a realistic experience.

To satisfy RO4 - investigate if the incorporation of emotions into virtual agents stimulate a better set of responses from the human user.

To satisfy RO5 - investigate if emotional virtual agents can have an effect on the learning experience.

To satisfy RO6 - investigate if emotional virtual agents allow the learners recognise their emotions and understand how these affect the virtual agents and, subsequently, allow them to feel more empathy towards them.

5.1 Qualitative data coding

In the table below the coding relating to the four research objectives is listed. Four distinct codes were used for the four different themes related to the research objectives. In the nine tables that follow the number of occurrences that support each research objective for each of the nine participants are listed.

RO3 - The investigation of if a virtual learning scenario incorporating emotional virtual agents provides a realistic experience.

RO4 - The investigation of if the incorporation of emotions into virtual agents stimulate a better set of responses from the human user.

RO5 - The investigation of if emotional virtual agents can have an effect on the learning experience.

RO6 - The investigation of if emotional virtual agents allow the learners to recognise their emotions and understand how these affect the virtual agents and, subsequently, allow them to feel more empathy towards them.

The occurrences of every time the participants referred to each of the four themes are summarised in the tables below. For example, the first participant (P1) mentioned four times during the interviews that the virtual learning scenario provided a realistic experience. These occurrences were marked by going through the transcripts of the replies of each participant (please see section 5.2.2).

1	REAL-EXP	Realistic experience (RO3)
2	BET-RESP	Better responses (RO4)
3	IMP-LEXP	Effect on Learning Experience (RO5)
4	INC-EMP	Increased Empathy (RO6)

Participant 1 (P1)

<u>TOTAL</u>	CODE	THEME
4	REAL-EXP	Realistic experience (RO3)
4	BET-RESP	Better responses (RO4)
4	IMP-LEXP	Effect on Learning Experience (RO5)
6	INC-EMP	Increased Empathy (RO6)

Participant 2 (P2)

<u>TOTAL</u>	CODE	THEME
--------------	------	-------

4	REAL-EXP	Realistic experience (RO3)
3	BET-RESP	Better responses (RO4)
3	IMP-LEXP	Effect on Learning Experience (RO5)
5	INC-EMP	Increased Empathy (RO6)

Participant 3 (P3)

<u>TOTAL</u>	CODE	THEME
2	REAL-EXP	Realistic experience (RO3)
3	BET-RESP	Better responses (RO4)
3	IMP-LEXP	Effect on Learning Experience (RO5)
4	INC-EMP	Increased Empathy (RO6)

Participant 4 (P4)

<u>TOTAL</u>	CODE	THEME
2	REAL-EXP	Realistic experience (RO3)
2	BET-RESP	Better responses (RO4)
2	IMP-LEXP	Effect on Learning Experience (RO5)
2	INC-EMP	Increased Empathy (RO6)

Participant 5 (P5)

<u>TOTAL</u>	CODE	THEME
1	REAL-EXP	Realistic experience (RO3)
1	BET-RESP	Better responses (RO4)
2	IMP-LEXP	Effect on Learning Experience (RO5)
1	INC-EMP	Increased Empathy (RO6)

Participant 6 (P6)

<u>TOTAL</u>	CODE	THEME
2	REAL-EXP	Realistic experience (RO3)
3	BET-RESP	Better responses (RO4)
1	IMP-LEXP	Effect on Learning Experience (RO5)
1	INC-EMP	Increased Empathy (RO6)

Participant 7 (P7)

<u>TOTAL</u>	CODE	THEME
7	REAL-EXP	Realistic experience (RO3)
2	BET-RESP	Better responses (RO4)
1	IMP-LEXP	Effect on Learning Experience (RO5)
2	INC-EMP	Increased Empathy (RO6)

Participant 8 (P8)

<u>TOTAL</u>	CODE	THEME
3	REAL-EXP	Realistic experience (RO3)
2	BET-RESP	Better responses (RO4)
3	IMP-LEXP	Effect on Learning Experience (RO5)
4	INC-EMP	Increased Empathy (RO6)

Participant 9 (P9)

<u>TOTAL</u>	CODE	THEME
1	REAL-EXP	Realistic experience (RO3)
1	BET-RESP	Better responses (RO4)
4	IMP-LEXP	Effect on Learning Experience (RO5)
3	INC-EMP	Increased Empathy (RO6)

The tables above illustrate how the scenario that provided text responses that were affected by the participant's personality traits and emotions, in addition to using visual and auditory cues, was more successful in providing a more realistic experience, better responses, improved learning and increased empathy. In the following section we will provide a detailed analysis of the qualitative data collected for this study.

The table below displays the same data organised by theme/research objective rather than by participant.

Theme	Total occurrences	Average occurrences per participant
Realistic experience	26	3
Better responses	21	2
Effect on Learning Experience	23	3
Increased Empathy	28	3
TOTAL	98	11

5.2 Analysis and Discussion of the qualitative data

5.2.1 Participant information and initial interview, before the virtual reality training session

All the participants were university nursing students with a special interest in mental health and particularly dementia. The students were at the end of the second year of their degree.

Participant P1 worked with dementia patients before and at the start of her training she found what she had to do quite intimidating, especially asserting her authority and being in charge of the patient.

“I noticed that every dementia patient I’ve worked with is different. Some can be really calm, normal one minute and then lose it the next minute and be really nice to you and then be really nasty to you; some can start telling you stories. At first I wasn’t sure whether to go along with it or say, “No, that’s not true.” But after speaking to a patient’s daughter she said can you go along with the story, because it will comfort the

patient, it will make him feel better because the patient actually thought he owed me money. I didn't want to say yes, obviously, but the daughter said it's in his mind and he's used to betting, he's used to owing people money so if you just say, "Yes, okay, give it me whenever..." then he should calm down."

P1 thought that online training could benefit nurses, especially in allowing them to experience the different possibilities of how a patient could react.

"I think training nurses could benefit from it because I know it's going to be different every time you go to a different patient, but at least if you've never been in that situation and you've done some online training you'd have a feel for what could possibly happen. I don't know, it could help with the different scenarios that you come across."

She had some previous online learning experience but not in using an immersive virtual world.

"I have, but not... it's more like questions and giving me a PowerPoint, reading through it, giving me all the information and then giving me questions at the end about it."

Feedback during those sessions was simply a Right or Wrong response.

"It was more of a pick the right answer question. So you done all the work, you read through everything and then you got a question at the end and you had to pick which one was the right answer."

Previous training included acting out scenarios with classmates and, once, with their tutor.

"We done it, we got into groups from our course and then one of the people in our groups would act as the patient. They'd been given a script of what do and then we'd have to deal with the scenario. One time we had to do it with the teacher, it was part of a test to see if we could do the A, B, C and D. The actors actually marked us on what we were doing right and what we were doing wrong and then told us at the end."

Regarding this kind of training P1 stated that it was not as realistic as she expected it to be due to having her friends playing the role of the patients.

"Mostly just reading things like answering questions and knowing what to say. The only thing about that is because we were all friends; it's completely different to a patient scenario

because you're kind of giggling. You know, you shouldn't be giggling but you're laughing because your friends are pretending to be some dementia patient and it's quite funny. So in a way it helps but it's completely different. Then when you've got... you're doing it (with real patients for observation purposes) and everyone else is watching you, you feel pressured and you just go out and cry."

When asked if she would prefer to train with real actors or online, P1 stated that actors would be preferable as she would learn more and also stated that, when using a computer, she may just lose interest and not learn as much.

"Yeah, I think why I say that is because I'm one of these people that learn from doing. So if I'm there doing it with the patient I know I'm learning at the same time. Whereas if I feel like I'm on a computer I feel like I could drift off sometimes and not take it all in."

The second participant, P2, also found working with patients with dementia very challenging.

"Yeah. Sometimes it's really difficult to communicate with them. Sometimes they don't really want to open up. I think it's difficult to build the trust as well with patients. It needs to take time for them to build trust between you and it's something that needs time and patience so trust is something that's really difficult but I've been able to do that and I've built trust with patients and...!

He did have some experience with online training before, mostly watching training videos and answering questions.

"Yes. There's instructions, there's audio videos to watch and then you can answer the question and instructions and yeah, and audios and videos, yes and it was helpful."

Feedback was provided either at the end of the session or every time he answered a multiple choice question.

"Sometimes it will be where whenever I finish a particular question and then sometimes at the end like the manual handling because it's a long one, then you get the results and everything and then sometimes you do one question and then you get feedback."

He also had the opportunity to take part in training where classmates were acting the role of the patient, which he found very useful.

“I think that’s a good learning experience because we’ve done you know, they’ve videotaped us doing clips of how you would communicate to a patient you know, who is really distressed. Yes I think that was helpful and then our mentors acting and you know, because you pick up what was right and what is wrong and how to communicate to patients. I think that was really good, the clips and then they recorded us. That was really a good learning experience.”

Participant P3 found that communication with patients with dementia was sometimes a challenge, especially when they had preconceived ideas of how a patient would react; this was based on input from other members of staff or students.

“I suppose when I was working with older adults I didn’t know what to expect because I’d never worked with them before and I did start my training on a dementia unit, so it’s how do you communicate with somebody who’s got dementia. I suppose the challenge can be preconceived ideas as well, some other staff, sometimes they give you insight and then you’ve got that in the back of your mind when you’re communicating with them as a patient. I suppose if they’ve had a background, if they’ve got background experience with that patient they’ll give you all the history and sometimes you’ll building up that idea in your head of what they’re going to be like before you meet them.”

P3 stated that she believed that online training could be helpful. The closest thing she did was when the tutor recorded a session with some of the students pretending to be patients. It was stressful initially but at the end the feedback and the ability to see themselves in the video was helpful.

“No, we’ve done... we did do a session where we were videoed and we had to communicate as if we were patient and staff, that was useful as well. Sometimes it’s how you phrase things and what tone you use as well, yeah, that could be a challenge and what information you’re giving, that it’s not clinical and that it is something that they can understand what you’re saying. Sometimes it can be blurred when you first train. To start with it was quite nerve-racking but actually when you got your

feedback it did really help how you could alter the way you're communicating because it got videoed as well we had a copy of that, so you could see yourself because sometimes you do stuff and you don't even realise that you're doing it so it's good to have that feedback so you can amend the way that you are."

The fourth participant found lack of knowledge one of the main challenges when working with patients with dementia.

"As a student working with patients I think some of its lack of knowledge because obviously as you go into training you have your theory but you're not going to know everything and experience gives you some of that knowledge but then it comes back to working within NMC requirements which is to work within your limitations and if you're not sure go and find a member of staff who is, and I think that takes a little bit long."

She explained that online training could be useful but only if it was designed properly.

"I think that would depend on how you draft it. I think if it was...because if it's very much read something on the screen, add some questions, that can get very tiring on the eyes. On the other hand an example is in one of the modules I did earlier in the year, first semester, we had on where we were directed to go to training on doing injections, which we watched together and it gave me some examples...gave...you listened to some audio, some...saw some...you know information on the screen. Very helpful, and then you were asked questions on it and you could keep repeating until you've got your understanding, you know you've got it...you were getting the full marks on the test. So it was kind of like, it was very interactive and I think if the online training is geared towards different modes of learning or training you know..."

She then noted that they are using online material for the course she is taking, which she finds very useful.

“Yeah I mean we have got training facilities which we use at university which when we...if you’ve had a live session or like a skills live session, or before we have that skills live session we can go and load and it’s basically like pdfs but on screen. You can actually read through what you have to do at each step, each stage on that skill. The same for ...there’s other things on the internet as well which from...like around nasal gastric tubes, how to insert flow charts and those sort of things. So it doesn’t...the university uses quite a lot of interactive stuff on the point of where we need to go to get it. So unless we get those parts of the lectures and we might get some tests or some information embedded into as an object into just to read through. Certainly with our RPR module, a lot of that is online so you’ll get some...you’ll have some weeks where you have to do the online content, listen to videos, read the content and then do some tasks at the back of it, but then you’ll have a teaching session where you’re with the lecturer and probably two or three move backwards, two or three or four times in a year. But most of that learning you’ve got a few weeks when you’re doing it directed so...”

Finally P4 explained how they use interactive training either with the help of classmates and the lecturer or by working with a SimMan (interactive patient simulator, <http://www.laerdal.com/doc/86/SimMan>).

“We’ve done them...well it depends what. We’ve got skills now, we’ve got Sims man. So he’s a dummy and he can...how can I put it? Portray or put across different conditions but he’s a plastic dummy. We can carry out skills on the dummy. I mean I learnt how to catheterise using a dummy but at the same time it also had in our...in one of our modules we had a case study situation. We’ve had a lecturer acting in one care, in one patients role and then we’ve had a an actual service user acting out the other role so the two we’ve had and they

basically then...oh gosh...play act the role and then we work out what's up. So we've had them in everything."

Participant P5 believed that working with patients can be challenging but she could learn a lot by the patients themselves.

"It's a learning curve. I feel like I learn more with the patients because they are the masters of their own conditions. Sometimes they know more than me which is frustrating, but that's to be expected – especially just because I am being on placement; but I've been working on it, so... That's all you can do really, isn't it?"

But even though patients seemed to know a lot about their condition there were times that things got difficult, something that is especially common with patients with dementia.

"Oh yes, being kicked and stuff like that. I always say I'm more likely to get... I work in an adult home as well as my part-time job. I work with an elderly and sometimes their frustrations within the environment, you're more likely to get hit by an adult ward than a mental health ward, but people always perceive it differently. They always ask me, "Are you scared to go into work?" I'm like, "No, I'm not in a mental health ward, but an adult ward.""

She believed that online training could really help as it is difficult to find patients or other people to practise with as most people are usually very busy.

"Definitely. 'Cause a lot of people don't have time to give you face-to-face. Everyone just assumes you're gonna learn it. It's a skill, but every skill needs something to back you up with. You can't mould anything from nothing."

P5 had some experience with online learning in the past.

“Yeah. I did my human resource diploma online. That was a degree – well, not a degree; it was a diploma. That was online with Leicester University. I’ve done a project management when I was younger and that was online. I like online distance learning, because you have support ‘cause you can email your tutor, but I find you can fit it in your own lifestyle.”

...but she had minimal experience with online learning during her current nursing degree.

“Not for nursing, except for the safe-medicate – the exam that we gotta do – that’s online. We’ve had to do a couple other things online for our modules. I do a lot of research online.”

The only interactive training with someone pretending to be a patient was during one of her classes.

“That was part of a lecture. It was a small group and the teachers were the patients and we had to be a nurse. I found that useful.”

The sixth participant, P6, found the changing mood of the patients to be particularly challenging during their training sessions.

“It’s hard because sometimes you end up in a place where they are approachable, but sometimes you find one or two that really give you a hard time. But that’s why we’re there and we need to help them go through their own process of being in hospital.”

Her online learning experience was through the university’s virtual learning environment.

“It’s really helpful, you learn a lot and sometimes they give you some case scenarios like videos on how to behave with patients or what training you have to do and how you have to deliver the service, yes. Sometimes there are Powerpoints, sometimes there are videos online that you can access and

then sometimes at the end you've got a couple of questions to answer or sometimes you have to discuss it in a group or in a lecture. Feedback is sometimes online and sometimes or it can be directly from my tutor in the lecture."

She also had the chance to try scenarios where tutors and classmates acted as the patient.

"Yes we can work with our own classmates and we pretend to be a particular patient ... it's an area and they can behave in one way or they could behave in another way and we've got the tutors around us and they're checking our reactions and how we manage the situation. Yes and sometimes the tutors they play the patient as well."

Participant P7 found it challenging when he had to work with real life patients, especially during his placements.

"I see myself as a people person, I'm quite, I don't know, like open with people and stuff. So I should say that my first year was a bit difficult because I did a placement with Dementia, some Dementia patients, so it was hard for me to understand what's going on, because it was my first time up there. So I had difficulty in getting into the student zone, like what am I supposed to do as a student? Am I doing the right thing? Am I talking to the patients the right way? But in terms of being afraid of the patient, no, I wasn't afraid. It was, when I did my second placement in Acute, I think I had the challenge of acting normal in front of the patient, but inside I'm thinking oh, what if she attacks me or, you know, but I was trying to keep that composure."

P7 did not have any experience with online-learning, his only experience with learning using a scenario was in a classroom setting.

“But we've done like, you know like in class we've done like scenarios with the lecturer and stuff but not actually something like video-like.”

He said that he believed that online learning may help him and it was something he would like to try.

The eighth participant commented on how he believes that one particular challenge is creating a relationship with the patient.

“Yes, there are always challenges within mental health, obviously. It's all down to how the patient is presenting at the time, I think. So, it's, I suppose the greatest challenge is the time it takes to create the relationship that you need to understand that person, you know. Because they don't know me, I don't know them and I suppose as part of my training, because I'm a Nurse aid, that we have to be aware that they are looking at us, assessing us in the same way as perhaps we are assessing them and... So we need to get to a point where perhaps we create that trust, that allows us then to have a relationship with them. So that is a challenge, you know, to...”

He believed that online training could be very helpful in helping them learn how to create this kind of relationship.

“Yes, that would be a big help, yes, yes.”

Only previous online learning experience was mostly guidance on using the web to find information, watching YouTube videos and then using the newly acquired information to answer questions on the subject in hand.

“Yes, yes. I mean the way they've set it, I mean I've just, before coming here now I was just doing some of that training. What they do is basically they give you some information, you know, and then refer you to some websites where there's more specific information and then there may be some YouTube, you

know, again with some more relevant information. And then, it's sort of, it's all set out like that and then afterwards you get a questionnaire, to check your understanding."

Finally he talked about role-playing in the classroom where the lecturer acted as a patient to help them learn about manual handling and crisis recovery.

"I suppose we only do that when we do manual handling and I suppose if we're using a bit of crisis recovery as well, you know, lectures where we have assimilated... you know, where you can have, we have a lecturer present as a patient, we have to be able to do role-play of how we would..."

The last participant, P9, expressed the belief that online learning could be used to enhance learning but could never be used to replace real life scenarios.

"I think there are some scenarios which could be illustrated online, because in practice students may or may not encounter different types of challenging situations. They may experience people with dementia, they may experience people with confusion, they may experience breaking bad news, but they may go through their entire training programme without actually experiencing that in practice. So I think the addition of an online teaching resource will make sure that all students are at least exposed to a simulated learning experience which is better than none, but I'm a firm believer that simulated and online experiences will never replace the total quality of experiencing that in practice. So whilst they're there to enhance I would agree, but not in place."

She then described the process of learning through training with real actors and SimMan.

"We've got a clinical skills lab and in that we have a high fidelity simulator, SIM MAN 3G. We use service users, so patients or

carers who the university recruit to take part in teaching. They give students feedback on how effectively they are seeking informed consent to have a procedure or practice done to. So there're service users, the simulation and actors, once professional healthcare actors were also used and that has been excellent in creating fairly realistic, extraordinary situations that only really a skilled actor or a skilled professional actor can do. Unfortunately the exposure to that has been reduced because of the significant cost of the actors, but it's something that I enjoyed and really saw the benefits of."

5.2.2 Thematic Analysis - Participant responses regarding the last four research objectives of this thesis

5.2.2.1 RO3 – investigation of if a virtual learning scenario incorporating emotional virtual agents provides a realistic experience.

Participant P1 found the scenario to be realistic, something that trainee nurses would expect to go through in real life, thus helping them immerse into the experience.

"Yeah, they (questions) were good because I imagined them actually happening in real life. They were good questions; they are the questions that come up on a ward. When I was completing it I was imagining myself being in that position on the ward so it was good."

The same participant also found the second scenario, that incorporated visual and auditory representations of how the person with dementia felt, to be more realistic.

"...the second one (was more realistic) because you got the reactions of happy and sad, that was obviously more realistic because you got a feel for what the patient was doing "okay I'm

happy with that or no, I don't want to do that" ... reading about an emotion not as effective as seeing body language. "

When P1 was asked if they felt that more similar training could help them improve their nursing skills further he stated that this would be the case, mainly because of the realism of the virtual learning scenario.

"Yes, would like more of this, it is like doing it in real life!"

Participant P2 also found the virtual environment to be realistic.

"Yeah, yeah it was because it showed you the emotions and the distress you have when you answer the questions."

P2 found the scenario questions to be realistic, similar to real life.

"I think yeah they are related to the questions we hear in the practice as well so there's no difference really. "

When he was asked to comment on if any of the two scenarios felt more realistic, P2 stated that he, also, found scenario 2 to feel more realistic.

"They're both realistic but I think the one with the emotions is better you know because it shows you how they feel because the first one didn't have the emotions because the second one is more...much better because it does show you the emotions."

Finally P2 expressed the wish to use a similar virtual scenario in the future as it helped him relate to what he experienced in practice.

"Yes, yeah because when you look at it you relate to what is seen in practice."

Participant 3 also thought that the scenario and the questions were realistic.

"Yeah, they were realistic, yeah. Some of the things were just very rude. Sometimes you do see that in the clinical environment."

She also find the second scenario to be more realistic.

“Yeah, they were both realistic because you do get asked for things all the time, like when you got the pop-up, that is reality, and the questions that they asked and how they do keep repeating themselves, that is realistic, yeah. The second one, that was more realistic having the smiley face and the sad face because that is how they react when you’re face to face with them.”

Participant P4 also stated that the scenario was realistic, especially because of the random distractions that made it feel like a real-life crisis.

“Yes, excellent idea having the other distractions come in because they do impact on your stresses in the situation and I think it’s also reading what it’s actually like. Even if you’ve got somebody else shouting at the same time, when I kind of put myself in that scenario I can say ‘Okay in that situation I’ve got somebody shouting; I’ve got this patient here’ but I’ve had to kind of work through the crisis of what I would be in that situation.”

P4 felt that similar training could help him improve his nursing skills further, in a similar way as when he trains with real people.

“Yes! We do not have service users (for training purposes) come in often, this offers a good alternative.”

Participant P5 and P6 found the virtual learning environment to be realistic, especially the graphics and sound, with participant 6 commenting specifically on the realism of the second scenario

“Yes, the second one was more realistic because of the change in mood (of the patient).”

The seventh participant found the environment to be realistic and the scenario and questions to be similar to the ones in real life training.

“Yes. It's (scenario and questions) what I've come across, not exactly but it's along those lines, what I came across during my placement.”

P7 also found the patient questions to be realistic.

“Yes they were. The questions they were asking, it's... I would think these were acting exactly like dementia patients.”

When the interviewer mentioned that these were indeed modelled after real patients' responses P7 noted that:

“Yes. They sort of like repeat themselves over and over, even if you tell them one thing, five or ten minutes later they will ask you something the same.”

P7 also found the second environment to be more realistic.

“Because... I think for Two you had like the patient's reactions, you could hear the sounds they were making. I can't say I could hear the sounds for the first patient but for the second one I did hear. “

And he continued to say that also the distractions, that felt more frequent and challenging in the second scenario, also contributed to the realism.

“Yes. Yes. And there were more distractions in the second scenario as well, which is very typical, more tricky for me.”

Participant P8 found the 3D environment, the questions and the responses to be very realistic. He also stated that the second environment was more realistic, especially due to the sounds the patient made when he expressed negative emotions.

“... you’ve got the sound and you’ve got the emotions... The scream is very useful because it takes you back to why do we all respond to babies? You know, any time anyone hears a baby screaming, it triggers something in you, doesn’t it?”

Finally, the ninth participant found the scenario and questions to be exactly like what she would expect to experience in real life.

“I think that’s exactly the kind of challenges that a healthcare worker will have. They will go into a bay, they’ll be approached by one patient but there will be others also demanding on their time, there’ll be other important tasks and it’s important to make sure that the patient is cared for and you also meet the needs of others. So the scenarios felt very real to me.”

Summary

In this section it was investigated if affective virtual agents provide a more realistic experience. Both the replies to the interview questions and the observation from the researcher provided data that supported the research objective and, subsequently, the research question. More specifically the participants reported that the scenario questions were realistic and made them feel that they were interacting with a real patient, especially in the case that the patients reacted in a way that made their emotions clear. They also felt that the realism of the scenario could help them improve their nursing skills, especially with the integrated distractions which corresponded to what they would expect to have to deal with in a real world scenario. They found that the realism of the system could provide a good alternative to training with service users (real people) during either their studies at the university or their placements. The realistic sounds from the patients (laughter screams etc.) were also found to be very useful and increased the realism of the whole experience considerably.

5.2.2.2 RO4 - investigation of if the incorporation of emotions into virtual agents stimulate a better set of responses from the human user.

Participant P1 was asked to comment on how reporting his emotions, stress and agitation between every response improved, if at all, his understanding on how the emotions he felt could affect the patient. His response was that it helped him realise that the way he coped with these emotions could affect the end result.

“... in one of the questions the patient was shouting, he wanted to get out of there. If I was shouting back it would have escalated, it would have made the patient more angry, whereas if I just calmly say we can help then at least the patient’s hear that there is some help for them.”

He continued to say that reporting these emotions helped him to try to control them.

“... so I’ve got to keep it in and just find an easier, calmer way to say, ‘Let’s sit down and we’ll sort it out.’”

Also P1 said that asking him to report these emotions helped him think about how he felt and prompted him to try and choose the answer that would make it less likely to transfer any negative emotions onto the patient.

“Yeah, because there were some answers that I was reading and I thought if I answer with that it will make the scenario escalate and make the patient more agitated and angry if I tell them, “Oh just sit down, I’ll deal with you later.” They don’t feel like they’re being cared for so they’ll just want to leave, they won’t want to sit down and talk to you but if you say, ‘Sit down, I’ll get you a drink and we’ll talk about how worried you are.’”

Finally, participant 1 said that changes in the patient's mood make it clearer on how his replies affected the patient.

"It made me realise that the way I..., you just simply talk to a patient the way you put a question can be the difference in an angry patient or a calm patient. You can say two things in two separate, different ways, but one comes out a lot more than the other."

The second participant, P2, discussed that reporting her emotions helped her realise how to best reply to the patient.

"Keep them calm because when you answer them in a rude way that's when the situation really escalates."

She also pointed out that the visual changes on how the patient felt in the second part also affected the way she felt.

"...yeah feeling happier yeah because it was helping every time I say the right answer, he was happy and it made me feel happy you know as a person because I've made something good for him and he's not crying or screaming or trying to leave the hospital."

Finally, she commented on how a clearly unhappy patient, using the visual and auditory clues in the second scenario, would make her feel.

"...did I do something wrong? Is there anything else I could have done better? Is it communication or could I have improved you know? Maybe I needed more time to attend to her."

Participant P3 was asked to comment on how the animation, emoticons and audio showing the patient's mood affected, if at all, his feelings.

"Sometimes where you've got that role to fulfil it's hard to balance the two (role and emotions) but it did make me think

she was sad. So if that kept happening in more scenarios I would have reflected on how I did respond to her.“

P3 went on to describe how learning through an online scenario could have an effect on his learning experience.

“Learning online is more of a safe environment ... I mean if you got it wrong practising in real life with real patients or in front of your tutor... when I got that one question wrong I'd feel embarrassed, and that would have made me to get even more wrong.“

Finally the participant discussed if he felt that more similar training could help him improve his nursing skills further.

“Yes! It could help stop a patient become agitated in real life. It teaches you that it CAN be prevented. It is how you respond (that matters).“

Participant P4 stated that reporting her emotions helped her think about the reply she was about to give to the patient a bit more carefully.

“Yes that did because obviously if my emotional stress is up the top end I'm going to have to think a bit more about what I will say, how I will reply.“

She also went on to explain that the visual and auditory changes in the patient's mood in scenario 2 affected her feelings during the scenario.

“Yes, it made me realise that it is all about managing patient emotion, and how I reply will surely affect that.“

P5 also discussed that reporting his emotions helped him realise better which reply to choose so that he would not affect in a negative way the way the patient felt.

“Yes, it indeed helped me decide on the best possible answer so that I could help the patient feel better as I knew how I felt and how my feelings could potentially make things worse“

P6 also noted that seeing the patient demonstrate her mood in the second part of the scenario, i.e. showing that she was happy or showing that she was upset, also affected how she (P6) felt during the scenario.

“Yes it affected how I would approach the next step. Also the change in the patient’s mood helped me understand if I got it right, how my response affected her.“

The seventh participant stated that thinking about his emotions, did indeed help him try to control them.

“Yes. Yes. I think trying to speak to them in the right way would actually calm them than being rude to them which will make them worse, make the situation worse.“

He also confirmed that reporting his emotions, make him try even harder to choose the answer that wouldn't make things even worse.

“Yes because if I'm more agitated I will make sure that I say the right things, so maybe that would influence my answer“

Participant P8 felt that reporting her emotions made her more likely to think about them and try to control them.

“That’s right, yes, yes. Makes it clear that you have to reply more calmly. So you need to think “What is he on about?” It might be that they just want a cup of coffee, which they can make themselves, but on this occasion they’re demanding that

you make it for them and perhaps a gentle answer might be “Look, I understand that you would like me to make you a cup of coffee but part of the reason why you’re here is that you’ve got to look after yourself. The coffee is there, the hot water is there, just help yourself to them”. As opposed to “Make it yourself!” “

“It’s important not to allow your emotions to affect the patient!”

Finally the last participant, P9, noted that the second scenario would help somebody learn better how to respond to a patient because of the notable changes to the patient’s mood.

“Yes, yes. Definately helps you think how your response can affect the response and mood of the patient.”

Summary

In this section it was investigated if affective virtual agents stimulate a better set of responses from the human user. Both the replies to the interview questions and the observation from the researcher provided data that supported the research objective and, subsequently, the research question. More specifically, the participants reported that the emotionally enhanced training scenario made them realise how their actions can affect the patient’s mood and subsequent reactions and how by being calm and not letting their emotions guide their actions they can help the patients much more. They also agreed that seeing how happy the patient was because of their care also improved their mood so it was really a two way street. The affective virtual agents also made the participants reflect on their work, when the results were positive but, mostly and more importantly, when they did not succeed in keeping the patient happy. The online training environment also helped them respond better as they felt more secure not having to deal with real patients while still at the initial stages of learning as the embarrassment of getting one question wrong in a real world scenario would sometimes stress them and, subsequently, make them get more wrong answers.

5.2.2.3 RO5 - investigation of if emotional virtual agents can have an effect on the learning experience.

Participant P1 discussed how the second scenario affected the learning experience while he was going through it.

“Yes, it did affect my learning, because when I answered the questions right and they were happy it made me think I’m doing something right, I’m calming the patient down. Whereas if they’re angry and they want to shout at you then I am not doing the right thing. “

He then explained if he thought that one of the two scenarios helped him learn better.

“I’d say the second one definitely made me learn better because obviously I got the first wrong because I thought about how I’m actually answering the questions and how it’s affecting the patient. I’d say if I wasn’t getting a response from the patient it wouldn’t have changed my train of thought. “

P1 also noted that the clearly displayed emotions of the patient during the second scenario affected the way she felt.

“Yes because when I got the first one wrong, I thought oh gosh, like obviously I’d get slightly more stressed because the patient is getting stressed and I don’t want them to get even more worked up, I wanted them to calm down.“

The second participant was asked if she thought that any of the two scenarios could help her learn better.

“Yeah. I think it’s a good learning experience ... the second one helped me learn better I think because it shows that it’s very important if you know how somebody feels after you’ve done something for them.“

When P2 was asked to comment on if the changes in the patient's mood in scenario 2 affected her feelings she stated that it helped her think about what she could do in order to make things better.

“Yes they did, and made me think ‘what could I improve?’ to make things better for the patient, make her feel better.”

The participant was also asked to comment on if she felt that having more similar training could improve her skills even more.

“Yes it could because ... it does help because it’s real. You know when you relate to what you’ve seen practice. It’s like the educational games that kids play these days, some are very good for teaching them things.”

Regarding which of the two scenarios helped him learn better, participant P3 confirmed that the second scenario worked better for him due to the visual representation of emotions.

“Yeah, the second one, because say when it was a sad face, it made me realise better what happened.”

The same participant also discussed ways it would help a carer improve when taking part in the online training scenario.

“So like when we did it face to face with a member of staff in a way you could feel that you were being judged by that member of staff. I suppose to test out your skills first online then you’re sort of in a safer environment than when you’re face to face with somebody. Learning this online is more of a safe environment to get it wrong and where you can get your skills up to scratch really to be able to do it face to face with somebody.”

Participant P3 continued to say that the scenario also helped him understand that he can control what will happen between him and the patient.

“Also I suppose some people don’t have that when they’re on placement because it’s horrible when a patient does get angry at you, and if you can stop that happening both your

experience and the patient's experience is always better really. So it just teaches you that it can be prevented because sometimes with mental health there is that assumption that everybody is going to shout at you and actually it's showing people that it's how you respond, not just because they've got a mental health issue"

The fourth participant noted that trainee carers can be made more aware of their own emotions by reporting them during the training scenario and how these can affect their behaviour.

"...because it's a way of saying 'look you need to watch you're saying, what you're doing, what's your emotions' because behaviour is behaviour basically and I think that has a big impact."

Participant p4 also felt that similar training could help her improve her nursing skills further.

"I think so (my skills could be improved). Certainly the people side of skills because everybody has their own individual personalities and this gives you another element of interacting with the service user. At the moment we have service users that come into the university, we don't have that very often...well it's usually per by a module but this gives you another way of getting that and whether or not we like it we've got Sim man and you've got programmed specific you know, conditions that you can replicate. Whether or not you have a similar sort of different patients with different conditions, different questions so I can definitely see an application for it."

Participant P5 stated that reporting her emotions affected her experience.

"Yes, it made me stop and think, realise how that could affect what I was doing."

And confirmed that she would be interested in taking part in more training scenarios in the future.

“Yes, that’s a good way to learn. The session was very useful and helped me learn a lot.”

Participant P6 found the scenario questions to be helpful for his training and very realistic.

“They were very good questions, very realistic, and helped me learn how to work with the patient.”

The seventh participant felt that having more similar training in the future could help, particularly if it was integrated into their university course.

“Definitely. I wish we had these sorts of things, like maybe on our website, where we could do these things at home as sort of almost like everyone for a practice and stuff. So, but at the moment we don’t have anything like this so I think it would be quite helpful if they actually incorporate to our studies as well - it will help.”

Participant P8 commented that by seeing that the patient was happy, by smiling or laughing a little, made him aware that his caring approach was the correct one.

“Yes, it made me feel as though I was on the right track with the individual, seeing him happy!”

P8 also noted some of the reasons why the second part of the scenario was better.

“So it’s important to have that kind of element in something like this because it can make the person realise that this is a distress situation and people have to think of their emotions, to say “Okay, what do I do about this?” It’s almost the first sign, you know, of getting someone to panic or to react. This is often what, when the patients scream, they’re looking for some kind of reaction.”

And, finally, she stated that having more, similar, training in the future could help improve the nursing skills of her and her course-mates.

“Oh yes, yes, yes. Once they if possible understand the reason behind why we’re doing that particular set of actions, through

reflection rather than through being told, you will find that it will give the opportunity to be able to grow in an intelligent manner.“

The last participant, P9, also believed that reporting her emotions helped her realise how she felt more clearly and, subsequently, helping to try to control them more.

“My emotions... positiveness, that positive feedback helped me and stopped me from becoming anxious because it was a positive reinforce... a positive feedback, so yes it helped me control my emotions. Had I been getting the scenarios wrong I think that negative feedback would have made me feel less sure of myself and more anxious.“

Also by reporting her emotion and its strength helped her realise more clearly how it could affect the patient.

“I think that’s the thing that’s missing in practice is that nobody tells you, you are so driven within the moment of stress that you don’t realise you are and you do need to take a step back. I think that’s perhaps the difference here between the virtual environment and the real environment, there is no button in the real environment to press, to gauge my anxiety or my stress, to help me realise it, to help me control it.“

P9 also reported that the changes in the patient’s mood, the visual changes and also the emoticons and the sounds used in scenario 2 affected the way she felt.

“It helped me realise how much help they need, it made me realise how dependent their behaviour is upon my behaviour.“

Finally, she went on to state how more, similar training, could help students improve their nursing skills.

“I do believe that because you’ve got the control here, haven’t you. In clinical practice, even though students receive exposure to the clinical learning environment in the care of dementia patients, dementia patients responses are so varied you never really know whether you’ve said the right thing

because the patient just may be beyond that state of mind to respond, to have a more positive response to what you've said although that might be the right thing. Here you've got that positive reinforcement that the kind of thing you're saying is the kind of right thing. So I think that would be very helpful."

Summary

In this section it was investigated if affective virtual agents can have an effect on the learning experience. Both the replies to the interview questions and the observation from the researcher provided data that supported the research objective and, subsequently, the research question. More specifically the participants stated that the feedback based on their responses made them understand clearly how their answers affected the patient and it allowed them to better understand how important it is to know how the patient feels at every stage of their interaction. They reported that the experience seemed realistic and close to what they would expect to do in real life and this helped them learn better. It was also something they found more enjoyable and less stressful as real life training scenarios sometimes made them feel uncomfortable and as they were judged by their tutor. They felt that these training sessions within a 'safe' environment would allow them to practice and improve their skills before attempting to work with a real patient. These training sessions also made them realise that this kind of training can also be applied to other patients with different conditions.

5.2.2.4 RO6 - investigation of if emotional virtual agents allow the learners recognise their emotions and understand how these affect the virtual agents and, subsequently, allow them to feel more empathy towards them.

Participant P1 commented on how having to report how stressed and agitated he was before every reply to a question helped him understand better how those emotions could affect the patient.

“Well, it made me really think of the patient. That it could escalate the patient’s condition and make him feel threatened if the trainee let those emotions show.”

In the same way he noted that reporting those emotions helped him think about them more, and, subsequently made him try to control them.

“Yeah, if I’m shouting, even though I might feel angry and just want to finish, if I show that it might make the patient feel threatened.”

P1 also stated that asking him to report those emotions helped him think about how he felt and to try to choose the right answer that wouldn’t affect the patient negatively.

“Yes, you may not have the time to and you may need to do other stuff but that way at least you’ve calmed the patient down a little.”

The same participant also found that by having the patient responding to him by moving around, making sounds and by showing emoticons affected his learning experience and made him feel more empathy towards the patient.

“...by seeing that how I feel it was affecting how they feel, because if they feel calm and happy then I know I’m giving them the right care.”

P1 also noted that similar training could help him improve your nursing skills further, specifically his compassion level.

“Yes, it could help me become more compassionate.”

Finally P1 was asked to comment on if any of the two scenarios make him feel more empathetic of the patient’s emotions.

“The second one, with the reactions, because it felt more realistic of the patient being there because you can read about an emotion but you can’t feel it unless you hear it or see it. A lot of that you couldn’t get through scenario 1. That person could say they’re fine but only their face and body can show that they’re not okay.”

The second participant also found that the second scenario made her more empathetic towards the patient.

“Yes, the second one as it is very important to know, to see, how someone feels.”

And commented further on how it would make her feel if the patient appeared to be unhappy.

“I would feel bad because I wouldn’t be able to control the situation if they are angry at me. I want...you know when you’re saying when he was angry, I wouldn’t be happy. It would affect me emotionally.”

She also noted that the changes in the patient’s mood in scenario 2 affected her feelings during the scenario.

“Yes, seeing the happy patient made me happy!”

In responding to the question if any of the two scenarios made her more empathetic towards the patient she responded that the second one worked better.

“Both of them yeah...both of them but then the second one is more because it shows the emotions so you know, if they’re upset it would...the second one is better because it shows the emotions, yeah!”

Participant P2 felt that more scenarios similar to the second one could make her feel more compassionate for the patient.

“Yes, if you’re somebody who’s really empathetic, you can...it can affect you as a person it depends because I’m somebody who’s got a passion for nursing and you know. I like what I’m doing. I just can’t wait to qualify, yeah.”

Participant P3 found that reporting his emotional state helped him understand better how his emotions could affect the patient.

“So she should just stayed calm didn’t she, the patient, because I was calm. So yeah, so if I got agitated that would be transferred on to the patient and they’d feel more agitated.”

When asked if the animation, emoticons and the audio in the second scenario affected their empathy towards the patient P3 stated that.

“Yeah, because the one where she looked upset that is what I’d do and that did indicate to me that that would make the patient upset.”

And also that

“The second one did work much better for me, all the ways for showing the patient’s mood really did make me feel for her.”

P3 also noted than online training similar to this one could also help people become more compassionate towards the patients.

“... because it’s highlighting your skills isn’t it, and making you aware of how that person feels.”

Participant P4 reported that in her case reporting her emotions in those scenarios also helped her try to think more carefully about her reply towards the patient.

“Yes, because if you feel you’re affected emotionally by the situation you do think about what it is you’ve got to say next and what you’re going to do next because you know that you don’t want your emotions to impact on the patient because it’s not about you, it’s about the patient and that side of care.”

Finally P4 stated that the changes in the patient's mood in scenario 2 affected her feelings.

“Yes! It made me realise how important it is to understand and try to manage the patient’s emotions.”

Participant P5 commented that the patient emotional responses affected him by helping him empathise with what the patient felt.

“Made me understand how they felt and how the situation affected them. Felt sorry for the patient when she got upset and I understood how she may have felt when she got angry and why.”

In a similar way the visible changes in the patient's mood in scenario 2 affected the feelings of participant P6

“Yes, made me feel happy with the happy patient, worse with the distressed one. “

The seventh participant felt that the visual changes on how the patient felt in the second scenario, along with the sounds and emoticons also affected her feelings throughout the scenario.

“Yes I think it made me feel better to hear the happy sounds than to hear the distressed sounds. So it makes me feel like I'm doing the right thing.”

P7 then stated that she would be very interested in the future in trying more, similar, scenarios.

“Yes, I would do yes. Because doing it as well makes me reflect and understand how the patient feels as well, so yes. I think that I will be interested to.”

Participant P8 noted that the emotions of the patient could be affected by his.

“Yes, the questions are very realistic and the responses ... and because we all come from a different place, with our own view of what's going on their mind is all different. One thing I have learned is that it's almost as if, you know when people are psychotic or in a bad place, they may not be able to reason logically but they're very, very good, for some reason, at

interpreting emotions. So therefore if you are presenting as angry, they may not hear your words, but they will feel your anger.“

And that reporting his emotions made him to think more about them and to try and control them.

“That’s right, yes, yes. Or at least make sure that the emotion that you are presenting is one that is not threatening, because it is easy, you know, to, you’ve had a bad day with the missus, or part of the time you’ve had a bad day at home and then someone now starts shouting at you on the ward.“

P8 also stated that the second scenario also made him feel more empathetic for the feelings of the patient.

“Yes, especially when, I suppose you know you look for triggers and you look for warning signs any time that patients are remotely in distress. My senses are heightened. It’s like you think “Oh okay, we don’t want this because it’s...” I suppose because I’ve seen it on many occasions where, if you don’t react quickly to an earlier sign of distress. Before you know, it’s totally out of control. So it’s very, very important that... I’m very switched on to the slightest sign of agitation coming from someone that is a patient.“

During the second virtual scenario training the participant said loudly and excitingly.

“I am happy if you are happy!”

And he finished by commenting positively on if he thought that future training using similar scenarios would be something he believed that trainee nurses should do.

“Yes because It is difficult to teach compassion. It is a big thing in nursing at the moment. If too compassionate you may go beyond the call of duty to ensure the wellbeing of the patient.“

Participant P9 was asked to comment if he thought that asking her to click on a scale of how stressed she felt, helped her realise that she was stressed and then try to control her stress because she realised that it could affect the patient negatively.

“It’s difficult to make that link. I think..., that’s the idea isn’t it, that by recognising it one can take control of your negative emotions, but I think that negative emotions are driven so much chemically aren’t they within the body, with adrenalin surges and things like that. So I would hope so, by getting you to realise, yes. I think that’s the thing that’s missing in practice is that nobody tells you, you are so driven within the moment of stress that you don’t realise you are and you do need to take a step back.”

When asked if the changes in the patient’s mood, the visual changes and also the emoticons and the sounds used in scenario 2 affected the way she felt P9 explained that this was indeed the case.

“Yes, they definitely did. The emoticons and the patient’s verbal and non-verbal communication, changed my mood and made me feel more empathic towards them, more aware of it what I was doing was the right thing or not. It helped me feel compassion towards that person. Made me understand how much help they need and how dependent their behaviour is on my behaviour.”

Finally participant P9 agreed that reporting her emotions during the scenario helped her understand better how these emotions can affect the patient.

“Yes! Thinking that positive feedback reduces anxiety but also that more people asking for things increases agitation. Higher agitation would affect the patient.”

Summary

In this last section it was investigated if affective virtual agents allow carers to increase their empathy. Both the replies to the interview questions and the observation from the researcher provided data that supported the research

objective and, subsequently, the research question. More specifically the participants reported that they realised how patients can feel threatened when carers let their negative emotions show and, on the other hand, how by seeing a patient being calm and happy they know that they succeeded in giving them the right care and they did not let their stress, anger or other emotions affect their work. The reactions of the patient in the second scenario made them realise clearly how the patient felt and made them try even more to be compassionate and calm and not allow their actions and reactions to have a negative impact on the patient. All the participants agreed that a happy patient made them feel happy and contented too whereas a distressed patient affected them negatively. One of the most satisfying moments observing the training session was when one of the participants just shouted out “I am happy if you are happy!” when she had a positive response from the virtual patient during the second scenario.

Within subject design (A/B testing) summary

The results of the comparison between the two different systems (presented above) are outlined below.

The system that provided the visual and auditory representations of the virtual patient’s emotions based on the participant’s emotions, personality and responses was reported to have the following advantages:

- Provided a more realistic representation of the carer/patient interaction
- Was better in helping the carers recognise how the patients feel
- Was better in helping the carers recognise and evaluate their emotions
- Was better in helping the carers realise how their actions can affect the patient’s emotional state
- Was better in helping the carers realise how their emotions can affect the patient’s emotional state
- Was better in helping the carers empathise with the patients

5.2.3 Data limitations

In more detail, the data collected and its limitations are as follows:

1. Observation data: The researcher observed the participants taking part in the two virtual scenarios and recorded observations on how the participants reacted to different parts of the scenarios. Visual expressions, gestures, comments and body language were observed for noting any discrepancies between these and the replies of the participants during the interviews that followed. The limitations of this data are as follows:
 - a. They can be viewed as too subjective as the observer can interpret what he sees and hears based on his expectations. To ensure that this limitation was minimised, in this thesis, the researcher only included observational data that were very clear-cut.
 - b. They depend on the role of the observer. If the observer is not very familiar with the research undertaken or does not have the necessary skills to correlate what he observes with the rest of the data then he may miss important observations. In this thesis, the observer was also the primary investigator so he was very familiar with every aspect of the research undertaken.
 - c. Overt observation may affect how the participants act and, thus, affect the validity of the findings. In this thesis, the observer sat as far away from the participants as possible and did not have any contact with them during the observation, trying to blend into the background so that the participants would not feel self-conscious.
2. Self-reporting data: The second type of data collected by the researcher was self-reporting data from replies to the semi-structured interviews both before and after the completion of the virtual scenarios. The limitations of this data are as follows:
 - a. Self-reporting can over-estimate adherence. To avoid this as much as possible the researcher did not specify which of the

two scenarios was the 'improved' one or made any other comments on how agreeable, or positive, any comments from the participants were during the interviews.

- b. Inaccurate self-reporting can be the result of social desirability bias. We aimed to minimise this limitation by having the focus on personal opinions of the suitability of the two scenarios rather than right or wrong answers that could affect how the participants chose to reply.
- c. The timeframe of the recollection can affect the self-reporting data collected. To minimise this limitation, the interviews were conducted immediately after the end of the two scenarios to make sure that the participants would have a clear recollection of the process.

5.3 Summary

This chapter described how the data was coded and interpreted. Thematic analysis was used for describing ideas within the interviews. The responses of the participants along with commentary by the researcher regarding both the replies and the observation of the participant while completing the scenarios were included in the chapter. This clearly demonstrated how the data corresponded to and helped satisfy the last four research objectives. In the following chapter we will discuss the results of the study and propose areas that would benefit from future work.

6. Discussion and Conclusions

6.1 Introduction

The aim of this thesis was to explore how Intelligent Virtual Agents (VAs) in healthcare provision training simulations can allow for a more effective level of understanding on how an emotionally enhanced scenario can affect different aspects of learning by responding to the human users' emotions and personality. An experimental framework for embedding emotions into virtual agents in virtual training applications for healthcare provision was developed and integrated into a prototype online training environment and nine case studies were conducted.

6.2 Chapter Summary

In the first chapter of this thesis the research context is introduced, outlining the need to create virtual agents that provide realistic and efficient responses while also helping the user to control negative emotions that may be introduced by stressful scenarios, something that can be achieved by endowing the virtual agents with capabilities for emotionally and socially intelligent behaviour. The aims and objectives of this thesis are then outlined, as well as its contributions to the field.

The second chapter consists of a literature review in the area of emotional computing and healthcare. The psychology of emotions is described, concentrating on negative emotions and stress, dementia and its effects on patients and carers, the incorporation of emotions into virtual agents, different ways of communicating emotions, ways of storing and retrieving emotion related data for online virtual training simulations and tools for discovering the personality types and traits of individual users. Dementia was chosen as the UK has an ageing population with growing numbers of people with dementia; research to support their emotional and physical well-being is needed (Alzheimers Society, 2015).

The third chapter focuses on the development of the framework and architecture for creating the emotionally intelligent agent, how the BDI model was improved and used for the purposes of this research, along with the Jboss DROOLS expert rules engine. The virtual scenarios and 3-dimensional world created with Unity3D as part of this thesis is described along with the user interface and the communication between the front-end the server, which can allow multiple users to go through the scenarios at the same time.

Chapter four describes the research design for the evaluation of the framework, the data collection and manipulation and lists the ethical considerations and limitations of this study. This leads to the fifth chapter which evaluate the qualitative data collected using semi-structured interviews and observation. The data were coded and, using thematic analysis, used to identify themes that allowed investigating if and how this data is consistent in supporting the research question and secondary objectives. The qualitative findings were consistent in supporting the research objectives and, subsequently, the primary research question. The participants of case studies did not simply support the research objectives with their replies to the interview questions, all of them were positive and enthusiastic and some of them even had a complete change of heart regarding the realism and usefulness of online learning environments for teaching trainee nurses on how to care better for patients with dementia.

6.3 Discussion and critical analysis

Based on the data analysis it can be concluded that the incorporation of emotions into autonomous software agents in virtual training applications allow for a more effective level of understanding on how an emotionally enhanced scenario can affect different aspects of learning (RQ). To reach this conclusion a framework for embedding emotions into virtual agents in virtual training applications for healthcare provision was developed (RO1), as well as prototype implementation of the emotional virtual agent framework (RO2). The replies of the participants and the data from their observation allowed to conclude that a virtual learning scenario incorporating emotional

virtual agents provides a realistic experience (RO3); incorporation of emotions into virtual agents stimulate a better set of responses from the human user (RO4); emotional virtual agents have an effect on the learning experience (RO5) and emotional virtual agents allow the learners recognise their emotions and understand how these affect the virtual agents and, subsequently, allow them to feel more empathy towards them (RO6).

Although previous research has taken into consideration the emotions of the participants, this research incorporates both the emotions and personality. In addition to this no other healthcare related research was identified that provided visual (emoticons and animations) and auditory responses based on the personality, emotions and the replies of the participants. Although this is a small scale study, a large amount of rich data were collected from each participant and these results will be useful for researchers in designing and conducting future studies relevant to a broader range of healthcare providers. The framework can be further adapted to be used in different and more varied fields, including crisis management and with both formal (e.g. soldiers, firefighters, law enforcement officers) and informal personnel. This can be done by using a different set of emotions for the participants; these can be negative, positive or include some of each type of emotion depending on the field and scenarios used. In addition to the participant's emotions, the virtual agent's moods can also be modified, again based on the aforementioned variables.

This thesis could be further improved in the future with additional research that would by address the following limitations:

1. Self-reporting of the participants' emotions: Evaluate the emotions of the participants using two techniques, and compare the results with the self-report of their emotions during the training scenarios; this can be achieved by; i.Using a camera with facial expression recognition and ii. Using a brain control interface and collecting raw data that can be analysed for eliciting the emotional state of the participants at specific times through the scenarios.
2. Limited generalisability due to the amount and type of participants: The study can be repeated with a larger group size to increase

generalizability. The participants can also include professional caregivers rather than being limited to nursing students. This will provide the researcher with an additional level of feedback that only more experienced professionals may be able to provide.

3. Limited generalisability due to the type of scenarios: The study can be extended to include different type of scenarios healthcare areas other than dementia (i.e. stroke, emergencies, operation theatre) but also areas other than healthcare (fire brigade, police, and army).

6.4 Future Work

In future work the author also plans to incorporate online assessment instruments into the virtual scenario for collecting quantitative data on how emotionally enhanced virtual agents could improve the learning experience of trainee nurses. Data collected from this and following studies will be used to create a set of guidelines for the production of online learning material that will help train both health professionals and informal carers.

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APPENDIX 1 – Ethical Approval Form

UNIVERSITY OF WOLVERHAMPTON

SCHOOL OF TECHNOLOGY

ETHICAL CONSIDERATION FOR RESEARCH PROGRAMMES

Section 1: Your details			
First Name & Surname:	Michael Loizou	Student No:	1026846
Project Title	Emotions for Intelligent Agents in Crisis Management Simulations in the area of healthcare provision		
Director of Studies:	Dr. Thomas Hartley		
Section 2: Your Project Topic			
2.1 What problem is this project addressing? (100 words or less)	The purpose of this study is to investigate how Intelligent Agents in Crisis Management Simulations in the area of healthcare provision may improve the learning experience by responding to user's emotions. For fulfilling the aims of this project the researcher will contact approximately ten case studies. Case studies allow the study of a large number of variables in great detail and work well for developing and refining concepts (Cavaye 2008) ¹. The participants will be trainees in the area of healthcare provision. The design of the model and data collection instruments is based on input by psychologists and experts in the area of healthcare provision.		
2.2 Will information or artefacts resulting from your project be available externally to the University?	YES		

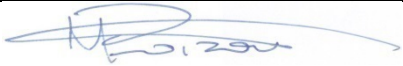
<p>2.2.1</p> <p>If you answered 'yes' to 2.2,</p> <p>will any such information place anyone at risk or possibly result in any action that might be detrimental to their wellbeing? (See guidelines)</p>	<p>NO</p> <p>No personal information will be collected from the participants and all data will be anonymised.</p>
<p>2.2.2</p> <p>in what format will the information or artefacts be made available?</p>	<p>Digital</p>
<p>Section 3: Method of Data Collection</p>	
<p>Please attach samples with this form if you intend to do interviews, surveys, or questionnaires.</p>	
<p>3.1 Does any part of your proposed project involve human participants?</p>	<p>Yes</p> <p>If 'no' proceed to section 4</p>
<p>3.2</p> <p>Please explain any aspects of the project, which might be detrimental to the wellbeing of any human participants in your project.</p>	
<p>It is possible that the participants might not find the responses of the virtual agents to their emotions agreeable. Their emotions may, thus, increase in intensity and duration while using the training software. This possibility will be minimised by adjusting, as needed, the responses of the virtual trainers to their emotions with the input of experienced psychologists.</p>	

3.3 Are there other ways you might meet your project aims without involving human participants? If not, why?	
No. The main aim of my project is to investigate how incorporating the ability to respond to emotions into virtual agents may improve the learning experience. The only way to test the hypothesis is to research if and how user's learning improved is to use humans as participants.	
3.4 How will you select your participants?	
Convenience sampling. We will be using trainee nurses, specializing in the area of mental health	
3.5 How many participants will you contact?	
Approximately 10	
3.6 How will you approach potential participants? E.g. email, letter, face to face? Please append text of any letter or email	
The company will give the potential participants the appended information statement and consent form. The form lists the aims and data collection process of this research, in addition to the ways the data will be used and be disposed of when no longer needed. It also informs the participants of their right to withdraw at any time.	
3.7 Are your participants adults? (over 18 and competent to give consent) If no, answer 3.7.1. (See guidelines)	
Yes	
3.7.1 Are your participants	No

children or adults over 18 and not competent to give consent? If yes, why is it necessary to involve these participants?	
3.8 Are you offering any incentives to any of your participants, financial or otherwise? (See guidelines)	No
3.9 How much time do you estimate will be needed from any participants? (See guidelines)	4 to 6 hours
3.10 Please list the method of data collection and analysis intended to be used	1. Training virtual environment 2. Semi-structured Interviews
3.11 Will all of the data collected contribute towards your results?	Yes
Section 4: Confidentiality and data handling	
Please read methods of ensuring confidentiality in the guidelines.	
4.1 Will you ensure the anonymity of data collected from/about participants?	YES

4.1.1 Please explain how this will be achieved.	
The researcher will use anonymised data and no personal information will be collected from the participants	
4.2 Will you store/protect data collected from individuals e.g. password protected files?	Yes
4.3 Once your project is complete and information is no longer needed, will you destroy your data?	Yes
4.4 Will anyone else have access to the data collected?	No
If so, (i) please name the individuals and/or groups that will have access; (ii) why is access being given to those listed in (i)?	
Section 5: Working with other parties and companies	
5.1 Will you be using data on subjects held by another party or organisation?	No
If Yes,	

<p>(i) Please give details.</p> <p>(ii) How will you gain access to this information?</p>	
<p>5.2 Do you require written permission from a company, organisation or location, e.g. an employer or local authority?</p>	<p>No</p>
<p>If Yes,</p> <p>(i) Please complete an external agreement form and include this with your submission.</p>	
<p>NB: If working with another organisation or company please familiarise yourself with their Health & Safety procedures.</p>	
<p>Student's Declaration</p> <p>Sign and date against one declaration only</p>	
<p>Category 0.</p> <p>My project involves no human participation except for myself and I agree to ensure that any information or artefact produced will not be available outside the University.</p>	
<p>Category A1.</p> <p>My project involves limited human participation and I agree to ensure that</p> <p>(i) any such participation is not detrimental in any way to the interests of the participants;</p> <p>(ii) all information collected as a part of the project will be handled in</p>	

<p>(iii) accordance with the answers that I gave to question 4; No information or artefacts which may place anyone at risk or be detrimental to their wellbeing will be made available outside the University.</p>	 November 7 th , 2012
<p>Category A2.</p> <p>My project involves human participation and may present some risk to participants. I have considered alternative means of pursuing the project which do not entail this risk but believe that there is no practicable alternative. I agree to ensure that I take all necessary steps to minimise risks to participants and third parties. I agree not to proceed with any activities involving human participation until I have received approval from the Department Ethics Panel.</p>	
<p>Category B-E. My project does not conform to Category 0, A1 or A2. I have considered alternative means of pursuing the project which do not entail risk to human participants but believe that there is no practicable alternative to the proposal made. I agree to ensure that I take all necessary steps to minimise risks to participants. I agree not to proceed with any activities involving human participation until I have received approval from the School or University Ethics Committee, as appropriate.</p>	

<p>Director of Studies/Principal Investigator's Declaration</p> <p>Sign and date against one declaration only</p>	
<p>Category 0 or A1. I concur with the classification of this project as 0 or A1 and authorise continuation of the project pending consideration by the School Ethics Committee</p>	

<p>Other. I believe that this project should be classified other than 0 or A1. I will ensure that no activities involving human participants take place until and unless approval is granted by the School Ethics Committee</p>	
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Appendix 2 – “5 Factor Model” Personality Assessment Tool

Introduction

This is a personality test, it will help you understand why you act the way that you do and how your personality is structured. Please follow the instructions below, scoring and results are on the next page.

Instructions

In the table below, for each statement 1-50 mark how much you agree with on the scale 1-5, where 1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree, in the box to the left of it.

Test

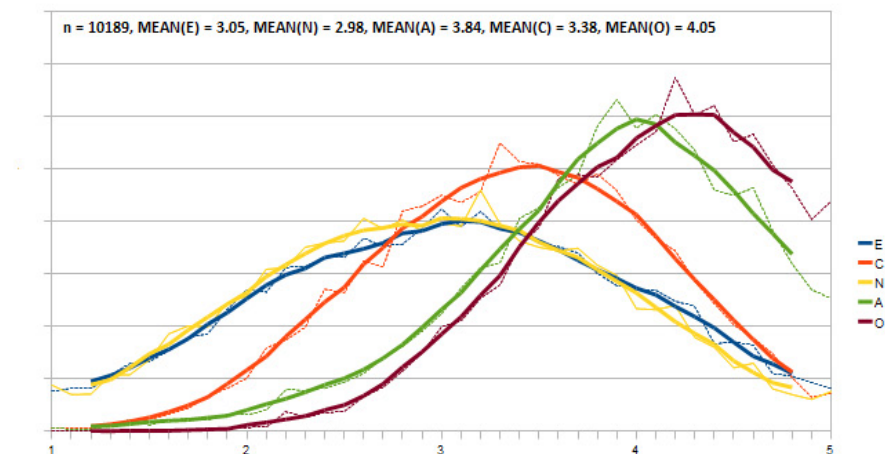
Rating	I....	Rating	I....
	1. Am the life of the party.		26. Have little to say.
	2. Feel little concern for others.		27. Have a soft heart.
	3. Am always prepared.		28. Often forget to put things back in their proper place.
	4. Get stressed out easily.		29. Get upset easily.
	5. Have a rich vocabulary.		30. Do not have a good imagination.
	6. Don't talk a lot.		31. Talk to a lot of different people at parties.
	7. Am interested in people.		32. Am not really interested in others.
	8. Leave my belongings around.		33. Like order.
	9. Am relaxed most of the time.		34. Change my mood a lot.
	10. Have difficulty understanding abstract ideas.		35. Am quick to understand things.
	11. Feel comfortable around people.		36. Don't like to draw attention to myself.
	12. Insult people.		37. Take time out for others.
	13. Pay attention to details.		38. Shirk my duties.
	14. Worry about things.		39. Have frequent mood swings.
	15. Have a vivid imagination.		40. Use difficult words.
	16. Keep in the background.		41. Don't mind being the center of attention.
	17. Sympathize with others' feelings.		42. Feel others' emotions.
	18. Make a mess of things.		43. Follow a schedule.
	19. Seldom feel blue.		44. Get irritated easily.
	20. Am not interested in abstract ideas.		45. Spend time reflecting on things.
	21. Start conversations.		46. Am quiet around strangers.
	22. Am not interested in other people's problems.		47. Make people feel at ease.
	23. Get chores done right away.		48. Am exacting in my work.
	24. Am easily disturbed.		49. Often feel blue.
	25. Have excellent ideas.		50. Am full of ideas.

$$\begin{aligned}
E &= 20 + (1) ___ - (6) ___ + (11) ___ - (16) ___ + (21) ___ - (26) ___ + (31) ___ - (36) ___ + (41) ___ - (46) ___ = ___ \\
A &= 14 - (2) ___ + (7) ___ - (12) ___ + (17) ___ - (22) ___ + (27) ___ - (32) ___ + (37) ___ - (42) ___ + (47) ___ = ___ \\
C &= 14 + (3) ___ - (8) ___ + (13) ___ - (18) ___ + (23) ___ - (28) ___ + (33) ___ - (38) ___ + (43) ___ - (48) ___ = ___ \\
N &= 38 - (4) ___ + (9) ___ - (14) ___ + (19) ___ - (24) ___ - (29) ___ - (34) ___ - (39) ___ - (44) ___ - (49) ___ = ___ \\
O &= 8 + (5) ___ - (10) ___ + (15) ___ - (20) ___ + (25) ___ - (30) ___ + (35) ___ - (40) ___ + (45) ___ - (50) ___ = ___
\end{aligned}$$

The scores you calculate should be between zero and forty. Below is a description of each trait.

- **Extroversion (E)** is the personality trait of seeking fulfillment from sources outside the self or in community. High scorers tend to be very social while low scorers prefer to work on their projects alone.
- **Agreeableness (A)** reflects much individuals adjust their behavior to suit others. High scorers are typically polite and like people. Low scorers tend to 'tell it like it is'.
- **Conscientiousness (C)** is the personality trait of being honest and hardworking. High scorers tend to follow rules and prefer clean homes. Low scorers may be messy and cheat others.
- **Neuroticism (N)** is the personality trait of being emotional.
- **Openness to Experience (O)** is the personality trait of seeking new experience and intellectual pursuits. High scores may day dream a lot. Low scorers may be very down to earth.

Below is a graph of how other people scored when test was offered on the internet.



APPENDIX 3: SEMI-STRUCTURED INTERVIEWS

Part-1: Before completing the scenarios in the online learning environment

- Please tell me a bit about yourself, what year you are in your training, and your main areas of interest?
- What particular challenges do you face in your training when working with patients?
- Do you feel that online training is something that could help you improve working with patients?
- Have you done any online nursing training before and, if yes, how did you find it?
- Have you done any training with real actors before and, if yes, do you prefer training with real actors or virtual patients?

Part-2: After completing the scenarios in the online learning environment

1. How did you find the online scenarios?
 - a. Did you find them easy or difficult to go through? Please explain
 - b. Did these feel realistic:
 - (i). 3D environment. Please explain
 - (ii). Scenario / Questions. Please explain
2. Did reporting your emotions during the scenario help you understand better how these emotions can affect the patient? Please explain.
3. Did reporting your emotions during the scenario help you in thinking about and, subsequently, trying to control your emotions? Please explain.
4. Did reporting your emotions during the scenario help you realise how to best reply to the patient's next question? Please explain
5. Did the changes in the patient's mood in scenario 2 affect your feelings during the scenario? Please explain
6. Did the changes in the patient's mood in scenario 2 make it clearer how your replies affected her? Please explain
7. Did you find any of the two scenarios to:
 - a. Be more realistic. Please explain
 - b. Improve your learning more. Please explain
 - c. Make you more empathetic towards the patient. Please explain
 - d. Work better for you in any other way. Please explain
8. What changes would you suggest we make to future online training scenarios?
9. Do you feel that more similar training could help you improve your nursing skills further? Would it help you become even more compassionate with patients? Please explain
10. Would you be interested in taking part in more online training scenarios in the future?

APPENDIX 4 – Participant information statement and consent form

Consent Form



Date: .././....

PARTICIPANT INFORMATION STATEMENT AND CONSENT FORM

This research is undertaken as part of a doctoral project. The purpose of this study is to investigate how Intelligent Agents in Crisis Management Simulations in the area of health management may improve the learning experience by responding to user's emotions. For fulfilling the aims of this research, the participants will first use a virtual training environment, and then take part in a series of semi-structured interviews. The training environment will train the participants on how to respond to real-life scenarios in the area of health management.

If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without prejudice.

By signing this form you agree for the information gathered today to be used for this research.

All information you provide is considered completely confidential. Your name will not appear in any thesis or report resulting from this study, however, anonymous quotations may be used. The data generated in the course of the research will be retained in accordance with the University's policy of Academic Integrity and will be kept securely in paper or electronic form for a period of five years after the completion of the research project.

If you have any questions, please feel free to ask us by emailing any of the investigators.

<i>TITLE & NAME</i>	<i>POST</i>	<i>DEPT & SCHOOL</i>	<i>EMAIL</i>
Dr. Tom Hartley	Director of Studies	School of Technology - University of Wolverhampton	T.Hartley2@wlv.ac.uk
Prof. Robert Newman	Supervisor	School of Technology - University of Wolverhampton	R.Newman@wlv.ac.uk
Dr. Sarah Slater	Supervisor	School of Technology - University of Wolverhampton	S.I.Slater@wlv.ac.uk
Mr. Michael Loizou	Investigator	School of Technology - University of Wolverhampton	Michael.Loizou@wlv.ac.uk

1.	I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	<input type="checkbox"/>
2.	I give my permission for the learning materials as well as all the data collected to be used by the investigators	<input type="checkbox"/>
3.	I agree to take part in the above study	<input type="checkbox"/>

Please Sign here

APPENDIX 5 – SAMPLE SCENARIO

Sample questions and possible answers for the interaction between the participants and the virtual patients

Question 1

Patient : “Do not tell me what to do, I will not sit down, I want to get out of here!”

Response 1: “Mrs Smith, stop shouting, shouting is not allowed and it is very unhelpful”

Feedback: This is not a helpful response. It is defensive and does not make Mrs Smith feel that the nurse understands her level of agitation or distress. This will not reassure Mrs Smith in any way.

Response 2: “Shouting at staff is not allowed in this hospital”

Feedback: This is not a helpful response. It is defensive and does not make Mrs Smith feel that the nurse understands her level of agitation or distress. This will not reassure Mrs Smith in any way. Mrs Smith does not understand that she is in hospital so she is unlikely to even consider hospital rules. These kind of statements may reinforce any ideas that she has about being kept against her will in an institution.

Response 3: “You are in Hospital and you have to stay in for quite some time.”

Feedback: This response does not give the patient any information to help her understand where she is and what is going to happen to her, or why she is there. This will lead to further questions and agitation.

Response 4: "I understand you are worried. You are in hospital and having some treatment for your painful knees"

Feedback: This is a good response; it gives the patient enough information that she can understand where she is. She may only be able to retain this information for a short time but the reduction in agitation may last longer. It is fine to repeat answers to questions that patients repeatedly ask. Often patients need to hear information several times to be able to assimilate the information.

Response 5: "I know you are worried about being here in hospital. Did you need to use the toilet"?

Feedback: This response reinforces the fact that Mrs Smith is in hospital, but it also offers a possible reason for being worried. This may be the problem or at least it makes Mrs Smith feel that the nurse is listening and interested.

Question 2

Patient: "This is the wrong place, I should not be here"

Response 1: "You are being very rude now Mrs Smith, calm down"

Feedback: Given this response, Mrs Smith may feel like a child being told off. It does not allow the nurse to explore what the problem might be. It is very likely that this response will lead to further agitation. This kind of statement may reinforce any ideas that she has about being kept against her will in an institution.

Response 2: "This is where you are being looked after, you do not have anything to worry about."

Feedback: This response does not give the patient any information to help her understand where she is and what is going to happen to her. This will lead to further questions and agitation. Telling someone who is agitated that they have nothing to worry about could instil further agitation. Mrs Smith may feel that no-one understands how worried she is.

Response 3: "I have told you before, but perhaps you have forgotten? You are in hospital."

Feedback: Mrs Smith may not recall any conversations at all. Reminding people that they have a memory problem is often unhelpful. It will feel like it is the first time she has been told that she is in hospital and will therefore want to know why.

Response 4: "Hello Mrs Smith, I know being in hospital makes you feel anxious, and we really want to be able to help. I think it would help if someone came to sit with you, we can then find out why you are worried."

Feedback: This is a positive response. This response reinforces the fact that Mrs Smith is in hospital. It enables Mrs Smith to feel that someone is listening to her and not dismissing her anxieties. It is likely that she will feel relieved that someone is going to help and this will reduce her levels of distress.

Question 3

Patient: "Should I be here in this place?"

Response 1: "Please stop talking to me and interrupting me while I am trying to do the medicine round"

Feedback: Due to cognitive impairment and certain parts of the brain being affected Mrs Smith is unlikely to be able to be empathetic towards others. This may make her appear ignorant, but this is not the case. Mrs Smith is unable to understand that the nurse should not be interrupted. Mrs Smith will feel that she is not being listened too and her response is likely to be defensive and will escalate her levels of distress.

Response 2: "I have told you before, but perhaps you have forgotten? You are in hospital"

Feedback: Mrs Smith may not recall any conversations at all. Reminding people that they have a memory problem is often unhelpful. It will feel like it is the first time she has been told that she is in hospital and will therefore want to know why.

Response 3: "You are in Hospital and you have to stay in for quite some time."

Feedback: This response does not give the patient any information to help her understand where she is and what is going to happen to her, or why she is there. This will lead to further questions and agitation.

Response 4: "I know you are worried about being here in hospital. Did you need to use the toilet"?

Feedback: This response reinforces the fact that Mrs Smith is in hospital, but it also offers a possible reason for being worried. This may be the problem or at least it makes Mrs Smith feel that the nurse is listening and interested.

Question 4

Patient: "Oh I am very mixed up, where should I be"

Response 1: "You are making it difficult for me to do the drugs and my other patients need their tablets."

Feedback: Due to cognitive impairment and certain parts of the brain being affected Mrs Smith is unlikely to be able to be empathetic towards others. This may make her appear ignorant, but this is not the case. Mrs Smith is unable to understand that the nurse should not be interrupted. Mrs Smith will feel that she is not being listened too and her response is likely to be defensive and will escalate her levels of distress.

Response 2: "You are in Hospital and you have to stay in for quite some time."

Feedback: This response does not give the patient any information to help her understand where she is and what is going to happen to her, or why she is there. This will lead to further questions and agitation.

Response 3: "I know being in hospital makes you feel anxious, and we really want to be able to help. I think it would help if someone came to sit with you, we can then find out why you are worried."

Feedback: This is a positive response. This response reinforces the fact that Mrs Smith is in hospital. It enables Mrs Smith to feel that someone is listening to her and not dismissing her anxieties. It is likely that she will feel relieved that someone is going to help and this will reduce her levels of distress.

Question 5

Patient: I am going now, show me the door!!!

Response 1: "Right, I am sorry Mrs Smith but if you do not stop shouting I will have to get security guards to come and deal with you."

Feedback: This is a very unhelpful response. Mrs Smith does not understand hospital rule and it is likely that she will interpret this response as a threat. It will increase her levels of fear and agitation. There is a risk that this response will scare her into wanting to leave and get away from the ward.

Response 2: "Mrs Smith, please sit down, this is very difficult for everyone around, please think of others."

Feedback: This response does not offer Mrs Smith reassurance or help. It is unlikely to reduce her levels of anxiety.

Response 3: "Why do you not let me help you feel better, would you like a drink?"

Feedback: This response shows the patient that the nurse is compassionate to her needs. This is reassuring and likely to reduce distress. It offers a solution.

Question 6

Patient: "Yes I am worried about things, can you help me"?

Response 1: "I will have to close this trolley and that will make people late having their tablets."

Feedback: Due to cognitive impairment and certain parts of the brain being affected Mrs Smith is unlikely to be able to be empathetic towards others. This may make her appear ignorant, but this is not the case. Mrs Smith is

unable to understand that the nurse should not be interrupted. Mrs Smith will feel that she is not being listened too and her response is likely to be defensive and will escalate her levels of distress.

Response 2: "Mrs Smith, you are being very difficult, I am trying to do the drug round, please sit down otherwise I will have to get someone to take you back to your chair."

Feedback: This response is not helpful. Whilst it gives Mrs Smith some information about why the nurse cannot come to her bedside, it could also be interpreted as a threat. It does not offer help but rather dismisses her anxiety.

Response 3: "Yes, I can help you. I need to stay with this trolley but Karen will come and talk to you to see how we can help."

Feedback: This response shows the patient that the nurse is compassionate to her needs. This is reassuring and likely to reduce distress. The nurse has been honest about why she cannot personally help but has offered to get someone else.

Question 7

Patient: "Why are you so nasty? Why will you not tell me why I am here, and when can I go home"?

Response 1: "Mrs Smith, you are shouting, please go and sit down and I will come and give you your tablets very soon."

Feedback: This is a very unhelpful response. It does not enable Mrs Smith to feel that anyone is listening to her but rather she is being told-off like a child. This is likely to increase her levels of frustration.

Response 2: "This is a hospital, you have been here for a week now, it is me, Nurse Jones, you know me."

Feedback: It is unhelpful to remind people that they have forgotten. This may make Mrs Smith feel even more anxious. She may also start to feel suspicious, as she has no recollection of previous conversations with Nurse Jones. If she has no recollection of being in hospital for a week she will feel anxious as to why she cannot remember this.

Response 3: "Hello Mrs Smith, I know being in hospital makes you feel anxious, and we really want to be able to help. I think it would help if someone came to sit with you, we can then find out why you are worried!"

Feedback: This is a positive response. This response reinforces the fact that Mrs Smith is in hospital. It enables Mrs Smith to feel that someone is listening to her and not dismissing her anxieties. It is likely that she will feel relieved that someone is going to help and this will reduce her levels of distress.

APPENDIX 6 – SAMPLE LOG OUTPUT

START

ANSWER|Dr

Hartley|VeryLowNeuroticism|Stress|1|Agitation|1|Q1|Which way do I go?|Q1A2|Q1A2T1|Mrs Smith, what do you want?

FEEDBACK|Q1A2T1F1|2.0|Mrs Smith may not be able to understand what it is she wants. She is feeling anxious and agitated. She may be hungry, in pain or thirsty but may not be able to realise what is making her feel the way she does. Sometimes if you suggest something that might be causing distress the person can associate with this and understand their feelings. For example if you acknowledge that she is upset or looking frightened, then ask : Mrs Smith do have some pain? she may be able to acknowledge she is in pain and say where this is.

PLEASE TRY AGAIN

ANSWER|Dr

Hartley|VeryLowNeuroticism|Stress|1|Agitation|1|Q1|Which way do I go?|Q1A2|Q1A2T3|Do you need something again Mrs Smith?

FEEDBACK|Q1A2T3F1|3.0|Whilst this response is asking Mrs Smith what she wants, the word AGAIN may make her feel that she is being a nuisance. This will make her feel low and agitated. Her levels of self worth may be affected here leading to her becoming anxious. She needs to feel valued and that those around her want to help. PLEASE TRY AGAIN

ANSWER|Dr

Hartley|VeryLowNeuroticism|Stress|1|Agitation|1|Q1|Which

way do I go?|Q1A2|Q1A2T2|What is it you want? Why are you out of your chair?

FEEDBACK|Q1A2T2F1|4.0|This response may make Mrs Smith feel like she is being a nuisance and that the nurse is fed-up of her. This will increase her levels of agitation and distress. Mrs Smith is responding to her feelings of anxiety, she may not be able to understand or articulate what her problem is. PLEASE TRY AGAIN

ANSWER|Dr

Hartley|VeryLowNeuroticism|Stress|1|Agitation|1|Q1|Which way do I go?|Q1A2|Q1A2T1|Mrs Smith, what do you want?

FEEDBACK|Q1A2T1F1|5.0|Mrs Smith may not be able to understand what it is she wants. She is feeling anxious and agitated. She may be hungry, in pain or thirsty but may not be able to realise what is making her feel the way she does. Sometimes if you suggest something that might be causing distress the person can associate with this and understand their feelings. For example if you acknowledge that she is upset or looking frightened, then ask : Mrs Smith do have some pain? she may be able to acknowledge she is in pain and say where this is. PLEASE TRY AGAIN

ANSWER|Dr

Hartley|LowNeuroticism|Stress|1|Agitation|1|Q1|Which way do I go?|Q1A3|Q1A3T2|Hello Mrs Smith, are you looking for the way?

FEEDBACK|Q1A3T2F1|1.0|This is a positive response. The nurse is reinforcing her name, showing that the nurse

knows her. The nurse is also offering to help. Mrs Smith may not know how the nurse can help but this is a good starting point. This response will enable Mrs Smith to feel confident to ask for something if she needs it. WELL DONE!

ANSWER|Dr

Hartley|LowNeuroticism|Stress|1|Agitation|1|Q2|Which way do I go?|Q2A3|Q2A3T1|Mrs Smith, you look worried, can I help you?

FEEDBACK|Q2A3T1F1|1.0|This response shows Mrs Smith that the nurse is compassionate to her needs, and wants to understand how she can help. This is very reassuring to Mrs Smith and is likely to reduce her levels of agitation as she begins to feel reassured that someone is being kind and understanding. She may not immediately become relaxed but if the nurse continues with this type of approach Mrs Smith is likely to become much calmer. WELL DONE!

ANSWER|Dr

Hartley|LowNeuroticism|Stress|1|Agitation|1|Q3|Do not tell me what to do, I won't sit down, I want to get out of here|Q3A3|Q3A3T1|I understand you are worried. You are in hospital and having some treatment for your painful knees

FEEDBACK|Q3A3T1F1|1.0|This is a good response, it gives the patient enough information that she can understand where she is. She may only be able to retain this information for a short time but the reduction in agitation may last longer. It is fine to repeat answers

to questions that patients repeatedly ask. Often patients need to hear information several times to be able to assimilate the information. WELL DONE!

ANSWER|Dr

Hartley|LowNeuroticism|Stress|1|Agitation|1|Q4|Do not tell me what to do, I will not sit down, I want to get out of here!|Q4A1|Q4A1T1|Mrs Smith, stop shouting, shouting is not allowed and it is very unhelpful

FEEDBACK|Q4A1T1F1|3.0|This is not a helpful response. It is defensive and does not make Mrs Smith feel that the nurse understands her level of agitation or distress. This will not reassure Mrs Smith in any way. PLEASE TRY AGAIN

ANSWER|Dr

Hartley|LowNeuroticism|Stress|1|Agitation|1|Q4|Do not tell me what to do, I will not sit down, I want to get out of here!|Q4A3|Q4A3T1|I understand you are worried. You are in hospital and having some treatment for your painful knees

FEEDBACK|Q4A3T1F1|1.0|This is a good response; it gives the patient enough information that she can understand where she is. She may only be able to retain this information for a short time but the reduction in agitation may last longer. It is fine to repeat answers to questions that patients repeatedly ask. Often patients need to hear information several times to be able to assimilate the information. WELL DONE!

ANSWER|Dr

Hartley|LowNeuroticism|Stress|1|Agitation|1|Q5|This is the wrong place, I should not be here!|Q5A3|Q5A3T3|Hello Mrs Smith, I know being in hospital makes you feel anxious, and we really want to be able to help. I think it would help if someone came to sit with you, we can then find out why you are worried.

FEEDBACK|Q5A3T3F1|1.0|This is a positive response. This response reinforces the fact that Mrs Smith is in hospital. It enables Mrs Smith to feel that someone is listening to her and not dismissing her anxieties. It is likely that she will feel relieved that someone is going to help and this will reduce her levels of distress. WELL DONE!

APPENDIX 7 – SOURCE CODE

Unity 3D (C#) - Random events script

```
using UnityEngine;
using System.Collections;
using System.Collections.Generic;

using MenuDisplayNS;
using System.Net.Sockets;
using System.Threading;
using System;
using System.Net;

public class Global
{
    public static bool firstContact = true;
    public static string userId = null;
    public static bool clickedOntutor = false;
    public static bool scenarioStarted = false;
    public static bool buttonsShow = true;
    public static bool taskButtonsShow = false;

    public static string qId = null;
    public static string qNo = null;
    public static string totalNumberOfQuestions =
null;
    public static string questionText = "";
    public static string selectedAnswerId = "";
    public static string selectedAnswerText="";
    public static string selectedAnswerTextId="";
    public static string[] answerTexts = new
string[10];
    public static string[] answerTextIds = new
string[10];
    public static string[] answerIds = new
string[10];

    public static string[] stringReceived = null;
    public static string emotion = null;
    public static string emotion2 = null;
    public static string agentName = null;

    public static string personality = null;
    public static float eScale = 0;
    public static float e2Scale = 0;

    public static string scenarioID;

    public static bool showRandomEvent = true;
```

```

        public static bool randomEventWindowVisible =
false;
        public static String randomEventText = "";

        public static string[] randomEvents = new
string[10];


        public static AvatarController avatarController  =
null;
        public static GameObject gameObject = null;

        public static int abort =0 ;
    }

public class start : MonoBehaviour {
    public char c;

    private MouseLook mouseLook1;
    private MouseLook mouseLook2;

    // Use this for initialization
    void Start ()
    {
        mouseLook1 = (MouseLook)GameObject.Find ("Main
Camera").GetComponent ("MouseLook");
        mouseLook2 = (MouseLook)GameObject.Find
("First Person Controller").GetComponent ("MouseLook");
        Global.gameObject =
GameObject.FindGameObjectWithTag("Avatar");
        Global.avatarController =
Global.gameObject.GetComponent<AvatarController>();

        Global.randomEvents[0] = "The bay phone is
ringing, it may be an emergency. Please click here to
answer it!";
        Global.randomEvents[1] = "Mrs Jones in ward 4
is calling. Please click here to ask another nurse to
help her!";
        Global.randomEvents[2] = "Mr Ali is shouting
again. Please click here to talk to him and help him
calm down!";
        Global.randomEvents[3] = "Mrs Cheng is
calling, saying that she is hungry. Please click here to
give her an apple!";
        Global.randomEvents[4] = "Mr Romanof is
calling, saying that he is thirstly. Please click here
to give him some water!";
    }
}

```

```

        Global.randomEvents[5] = "Mrs Roads needs to
go to the toilet. Please click here to ask another nurse
to help her!";
        Global.randomEvents[6] = "The patients
complain that it is too hot. Please click here to open a
window!";
        Global.randomEvents[7] = "The patients
complain that it is too cold. Please click here to turn
the heating up!";
        Global.randomEvents[8] = "Your supervisor is
paging you. Please click here to check what he needs!";
        Global.randomEvents[9] = "Your mobile phone is
ringing. Please click here to put it on silent!";

    }

    // Update is called once per frame
    void Update () {

        if (Input.GetKeyUp("2")){
            Global.scenarioID = "Scenario1";
            if(Global.clickedOntutor){
                mouseLook1.enabled = true;
                mouseLook2.enabled = true;
                Global.clickedOntutor = false;
            } else {
                mouseLook1.enabled = false;
                mouseLook2.enabled = false;
                Global.clickedOntutor = true;
            }
        }

        else if (Input.GetKeyUp("1"))
        {
            Global.scenarioID = "Scenario2";
            if(Global.clickedOntutor){
                mouseLook1.enabled = true;
                mouseLook2.enabled = true;
                Global.clickedOntutor = false;
            } else {
                mouseLook1.enabled = false;
                mouseLook2.enabled = false;
                Global.clickedOntutor = true;
            }
        }

    }

    public void OnApplicationQuit()
    {
        Global.abort = 1;
    }

```



```

    }

    void OnGUI() {
        //Console.WriteLine("1");
        //audio.Play();
        MenuDisplay NewMenuDisplay = new
MenuDisplay();
        NewMenuDisplay.OnGUI();
    }
}

```

Unity 3D (C#) - Main menu script

```
namespace MenuDisplayNS
{
    using UnityEngine;
    using System.Collections;
    using System.Collections.Generic;
    using System.Net.Sockets;
    using System.Threading;
    using System;
    using System.Net;

    public class MenuDisplay
    {
        public int labelFSize, boxFSize = 20,
buttonFSize = 40;
        int selGridInt = -1;
        int selGridInt2 = -1;
        int selGridInt3 = -1;
        string[] selStrings = new string[] { "1", "2",
"3", "4", "5"};
        string[] selStrings2 = new string[]
{"VeryLowNeuroticism", "LowNeuroticism",
"AverageNeuroticism", "HighNeuroticism",
"VeryHighNeuroticism"};
        public AudioClip angrysound;
        public AudioSource emotionsounds;
        public Texture      imageemotion;

        public MenuDisplay ()
        {
        }
        //
Global.stringReceived[Constants.FEEDBACK_PATIENTREACTION
_FIELD]

        public void OnGUI ()
        {
            // Change the font size for the label
            int backupLabel =
GUI.skin.label.fontSize;
            GUI.skin.label.fontSize = labelFSize;
            // Change the font size for the box
            int backupBox = GUI.skin.box.fontSize;
            GUI.skin.box.fontSize = boxFSize;
            // Change the font size for the button
```

```

        int backupButton =
GUI.skin.button.fontSize;
        GUI.skin.button.fontSize = buttonFSize;
        GUI.skin.label.fontSize = backupLabel;
        GUI.skin.box.fontSize = backupBox;
        GUI.skin.button.fontSize = backupButton;
        GUI.skin.box.wordWrap = true;
        GUI.skin.box.alignment =
TextAnchor.UpperLeft;

        if (!Global.clickedOntutor){
            if (!Global.buttonshow){
                GUI.Box (new Rect (
((Screen.width / 2) - 350), 220, 700, 25), "WHEN YOU
STOP MOVING Please press \'1\' for the first scenario or
\'2\' for the second scenario", GUI.skin.box);
            }
        }

        if (Global.clickedOntutor) {
            if (Global.firstContact) {

                //Register User
                ServerComms serverComms = new
ServerComms("http", "localhost", 8084,
"ScenarioServer/RegisterSession");

                serverComms.AddParameter("scenarioId",
Global.scenarioID);

                string textReceived =
serverComms.call();
                Global.stringReceived =
textReceived.Split('|');
                Console.Out.WriteLine("New
Session: " + textReceived);
                if (textReceived!=null)
                {
                    Global.userId =
Global.stringReceived[0];
                    Global.firstContact =
false;
                }
            }
            if (!Global.scenarioStarted) {

```

```

//GUI.Box (new Rect (80, 345,
700, 25), Global.stringReceived[1], GUI.skin.box);
GUI.Box (new Rect (80, 545,
700, 25), "Please enter your personality type as derived
from the test taken at the beginning of this session",
GUI.skin.box);

selGridInt2 = GUI.SelectionGrid
(new Rect (80, 575, 700, 30), selGridInt2, selStrings2,
5);

if (selGridInt2 != -1) {
    if (selGridInt2 == 0)
        Global.personality =
"VeryLowNeuroticism";

    if (selGridInt2 == 1)
        Global.personality =
"LowNeuroticism";

    if (selGridInt2 == 2)
        Global.personality =
"AverageNeuroticism";

    if (selGridInt2 == 3)
        Global.personality =
"HighNeuroticism";

    if (selGridInt2 == 4)
        Global.personality =
"VeryHighNeuroticism";

    Global.agentName = "Dr
Hartley";

//Get Next Question
(first)
ServerComms
requestNextQuestion = new ServerComms("http",
"localhost", 8084, "ScenarioServer/NextQuestion");

requestNextQuestion.AddParameter("uniqueId",
Global.userId);

String questionReceived =
requestNextQuestion.call();

Console.Out.WriteLine("QuestionReceived" +
questionReceived);

Global.stringReceived =
questionReceived.Split('|');

Global.scenarioStarted =
true;

}
}
else
{

```

```

                                if (Global.stringReceived
[Constants.TYPE_FIELD].Equals ("QUESTION")) {

        Global.avatarController.setState(AvatarConstants.St
and_Idle, false);

        ((MouseLook)GameObject.Find ("Main
Camera").GetComponent ("MouseLook")).enabled = false;
                                Global.qId =
Global.stringReceived [Constants.QID_FIELD];
                                Global.qNo =
Global.stringReceived [Constants.QNO_FIELD];

        Global.totalNumberOfQuestions =
Global.stringReceived
[Constants.MAX_NO_OF_QUESTIONS_FIELD];
                                Global.emotion =
Global.stringReceived [Constants.EMOTION1_FIELD];
                                Global.emotion2 =
Global.stringReceived [Constants.EMOTION2_FIELD];
                                Global.questionText =
Global.stringReceived[Constants.QTEXT_FIELD];

                                if
(Global.showRandomEvent) {
                                int currentTime =
(int)Time.time;
                                if
(Global.randomEventWindowVisible ||
((int)Time.time)%15==0){
                                GUI.color =
Color.red;

        GUI.ModalWindow(0, new Rect(900,150,400,300),
RandomEventsContents, "*** ATTENTION ***");

        Global.randomEventWindowVisible = true;
                                } else if
(!Global.randomEventWindowVisible) {

        Global.randomEventText = ChooseRandomEvent();
                                }
                                } else if
(!Global.showRandomEvent) {

        Global.randomEventWindowVisible = false;
                                }

                                GUI.Box (new Rect (80,
175, 700, 25), "Please enter a scale for the emotion " +

```

```

Global.emotion + " and then reply to the question below
- Current Value " + Global.eScale, GUI.skin.box);
        selGridInt =
GUI.SelectionGrid (new Rect (80, 205, 700, 20),
selGridInt, selStrings, 5);
        if (selGridInt != -1) {
            Global.eScale =
selGridInt+1;
        }

        GUI.Box (new Rect (80,
245, 700, 25), "Please enter a scale for the emotion " +
Global.emotion2 + " and then reply to the question below
- Current Value " + Global.e2Scale, GUI.skin.box);
        selGridInt3 =
GUI.SelectionGrid (new Rect (80, 275, 700, 20),
selGridInt3, selStrings, 5);
        if (selGridInt3 != -1) {
            Global.e2Scale =
selGridInt3+1;
        }

        GUI.Box (new Rect (80,
400, 750, 50), "(Q" + Global.qNo + " of " +
Global.totalNumberOfQuestions + ") " +
Global.questionText, GUI.skin.box);

        Console.Out.WriteLine
("Number of fields in response " +
Global.stringReceived);
        /*
        List<AnswerWrapper>
answerWrappers = new List<AnswerWrapper>();

        int countOfQuestions = 1;
        for (int
i=Constants.FIRST_ANSWER_FIELD;
i<Global.stringReceived.Length; i++) {

            Global.answerIds[countOfQuestions-1]=
Global.stringReceived [i];

            Global.answerTextIds[countOfQuestions-1]=
Global.stringReceived [i+1];

            Global.answerTexts[countOfQuestions-1] =
Global.stringReceived [i+2];

            AnswerWrapper wrapper
= new AnswerWrapper(Global.answerIds[countOfQuestions-

```

```

1], Global.answerTextIds[countOfQuestions-1],
Global.answerTexts[countOfQuestions-1]);

        answerWrappers.Add(wrapper);

                                i++;
                                i++;
                                countOfQuestions++;
        }

        countOfQuestions = 1;
        System.Random rnd = new
System.Random();

        while
(answerWrappers.Count!=0) {
                                int answerToDisplay =
rnd.Next(0, answerWrappers.Count); // creates a number
between 1 and 12
                                AnswerWrapper
answerWrapper = answerWrappers[answerToDisplay];

                                if (GUI.Button (new
Rect (80, 465 + (countOfQuestions) * 35, 700, 30),
answerWrapper.answerText, GUI.skin.button)) {
                                Global.agentName
= "Dr Hartley";

                                Global.selectedAnswerId = answerWrapper.answerId;

                                Global.selectedAnswerText =
answerWrapper.answerText;

                                Global.selectedAnswerTextId =
answerWrapper.answerTextId;

                                ServerComms
requestAnswerQuestion = new ServerComms("http",
"localhost", 8084, "ScenarioServer/AnswerQuestion");

                                requestAnswerQuestion.AddParameter("uniqueId",
Global.userId);

                                requestAnswerQuestion.AddParameter ("agentName",
Global.agentName);

                                requestAnswerQuestion.AddParameter ("emotion",
Global.emotion);

```

```

        requestAnswerQuestion.AddParameter ("emotion2",
Global.emotion2);

        requestAnswerQuestion.AddParameter ("questionText",
Global.questionText);

        requestAnswerQuestion.AddParameter ("qId",
Global.qId);

        requestAnswerQuestion.AddParameter
("selectedAnswerId", Global.selectedAnswerId);

        requestAnswerQuestion.AddParameter
("selectedAnswerText", Global.selectedAnswerText);

        requestAnswerQuestion.AddParameter
("selectedAnswerTextId", Global.selectedAnswerTextId);

        requestAnswerQuestion.AddParameter ("personality",
Global.personality);

        requestAnswerQuestion.AddParameter ("eScale",
Global.eScale.ToString("R"));

        requestAnswerQuestion.AddParameter ("e2Scale",
Global.e2Scale.ToString("R"));

                                String
answerQuestionResponse = requestAnswerQuestion.call();

        Global.stringReceived =
answerQuestionResponse.Split('|');

                                }
                                // Remove the answer
already displayed

        answerWrappers.RemoveAt(answerToDisplay);
                                countOfQuestions++;
        }

*/

                                if (Global.eScale==0 ||
Global.e2Scale==0) {
                                GUI.Box (new Rect
(80, 350, 750, 50), "Please select Emotions",
GUI.skin.box);

```



```

    }

    int countOfQuestions = 1;
    Console.Out.WriteLine
("Number of fields in response " +
Global.stringReceived);

    for (int
i=Constants.FIRST_ANSWER_FIELD;
i<Global.stringReceived.Length; i++) {

        Global.answerIds[countOfQuestions-1]=
Global.stringReceived [i];

        Global.answerTextIds[countOfQuestions-1]=
Global.stringReceived [i+1];

        Global.answerTexts[countOfQuestions-1] =
Global.stringReceived [i+2];

        if (GUI.Button (new
Rect (80, 465 + (countOfQuestions) * 35, 1500, 30),
Global.answerTexts[countOfQuestions-1],
GUI.skin.button)) {

            if
(Global.eScale!=0 && Global.e2Scale!=0) {

                Global.agentName
= "Dr Hartley";

                Global.selectedAnswerId =
Global.answerIds[countOfQuestions-1];

                Global.selectedAnswerText =
Global.answerTexts[countOfQuestions-1];

                Global.selectedAnswerTextId =
Global.answerTextIds[countOfQuestions-1];

                ServerComms
requestAnswerQuestion = new ServerComms("http",
"localhost", 8084, "ScenarioServer/AnswerQuestion");

                requestAnswerQuestion.AddParameter("uniqueId",
Global.userId);

                requestAnswerQuestion.AddParameter ("agentName",
Global.agentName);

                requestAnswerQuestion.AddParameter ("emotion",
Global.emotion);

```

```

        requestAnswerQuestion.AddParameter ("emotion2",
Global.emotion2);

        requestAnswerQuestion.AddParameter ("questionText",
Global.questionText);

        requestAnswerQuestion.AddParameter ("qId",
Global.qId);

        requestAnswerQuestion.AddParameter
("selectedAnswerId", Global.selectedAnswerId);

        requestAnswerQuestion.AddParameter
("selectedAnswerText", Global.selectedAnswerText);

        requestAnswerQuestion.AddParameter
("selectedAnswerTextId", Global.selectedAnswerTextId);

        requestAnswerQuestion.AddParameter ("personality",
Global.personality);

        requestAnswerQuestion.AddParameter ("eScale",
Global.eScale.ToString("R"));

        requestAnswerQuestion.AddParameter ("e2Scale",
Global.e2Scale.ToString("R"));

        String
answerQuestionResponse = requestAnswerQuestion.call();

        Global.stringReceived =
answerQuestionResponse.Split('|');

        Global.eScale=0;

        Global.e2Scale=0;

    }

    //sendCommandToJack ("ANSWER" + "|" +
Global.agentName + "|" + Global.emotion + "|" +
Global.message + "|" + Global.qId + "|" + Global.answer
+ "|" + Global.personality + "|" + Global.eScale);
    }

    i++;
    i++;
    countOfQuestions++;
}
}

```

```

                                if (Global.stringReceived
[Constants.TYPE_FIELD].Equals ("FEEDBACK")) {
                                    Global.showRandomEvent =
true;

                                ((MouseLook)GameObject.Find ("Main
Camera").GetComponent ("MouseLook")).enabled = false;
                                    String patientFeedback =
Global.stringReceived[Constants.FEEDBACK_PATIENTREACTION
_FIELD];

                                    GUI.Box (new Rect (80,
400, 1150, 60), "(" + patientFeedback + ") " +
Global.stringReceived [Constants.FEEDBACK_TEXT_FIELD],
GUI.skin.box);

                                if (patientFeedback ==
"0.0") {

                                    Global.avatarController.setState(AvatarConstants.St
and_Idle, false);

                                } else if (patientFeedback
== "1.0") {

                                    Global.avatarController.setState(AvatarConstants.Ha
ppy, false);

                                    imageemotion =
(Texture)Resources.Load("Icons/imageHappy");
                                    GUI.DrawTexture(new
Rect(500,300,100,100),imageemotion);
                                } else if (patientFeedback
== "2.0"){

                                    Global.avatarController.setState(AvatarConstants.Sa
d, false);

                                    imageemotion =
(Texture)Resources.Load("Icons/imageSad");
                                    GUI.DrawTexture(new
Rect(500,300,100,100),imageemotion);
                                } else if (patientFeedback
== "3.0"){

                                    Global.avatarController.setState(AvatarConstants.Di
sgust, false);

                                    imageemotion =
(Texture)Resources.Load("Icons/imageDisgust");
                                    GUI.DrawTexture(new
Rect(500,300,100,100),imageemotion);
                                } else if (patientFeedback
== "4.0"){

```

```

        Global.avatarController.setState(AvatarConstants.Afraid, false);

        imageemotion =
(Texture)Resources.Load("Icons/imageAfraid");
        GUI.DrawTexture(new
Rect(500,300,100,100),imageemotion);
    } else if (patientFeedback
== "5.0"){

        Global.avatarController.setState(AvatarConstants.Angry, false);

        imageemotion =
(Texture)Resources.Load("Icons/imageAngry");
        GUI.DrawTexture(new
Rect(500,300,100,100),imageemotion);
    }

    if (GUI.Button (new Rect
(330, 500, 50, 20), "NEXT", GUI.skin.button)) {
        ServerComms
requestNextQuestion = new ServerComms("http",
"localhost", 8084, "ScenarioServer/NextQuestion");

        requestNextQuestion.AddParameter("uniqueId",
Global.userId);

        String
questionReceived = requestNextQuestion.call();

        Global.stringReceived
= questionReceived.Split('|');

    }

    //(MouseLook)GameObject.Find ("Main
Camera").GetComponent ("MouseLook").enabled = true;
    //TODO: to be removed

}

    if (Global.stringReceived
[Constants.TYPE_FIELD].Equals ("END")) {

        ((MouseLook)GameObject.Find ("Main
Camera").GetComponent ("MouseLook")).enabled = false;
        GUI.Box (new Rect (80,
400, 750, 50), "Scenario end reached. Thank you",
GUI.skin.box);
    }

```

```

    }

//          } else {
//          ((MouseLook)GameObject.Find ("Main
Camera").GetComponent ("MouseLook")).enabled = true;
//          }
    }
}

private void RandomEventsContents (int
windowID) {
    if (GUI.Button (new Rect
(50,100,300,150),
Global.randomEventText)){Global.showRandomEvent =
false;}

    //print ("Got a click");
}

private String ChooseRandomEvent() {
    int eventChosen =
UnityEngine.Random.Range (1,10);
    return Global.randomEvents[eventChosen-
1];
}
}
}

```

Unity 3D (C#) - Emotional Animations & Sounds declarations script

```
using UnityEngine;
using System.Collections;

using System.Collections.Generic;
using System.Net;
using System.Threading;

public class AvatarController : MonoBehaviour {
    // Child Objects to animate.
    List<Transform> allChildren = new
List<Transform>();

    // The current State.
    private int currentState;

    // The current Event.
    private int currentEvent;

    // The next state.
    private bool nextStateSet = false;
    private bool runOnExitCodeForCurrentState = false;
    private bool targetSet = false;
    private int nextState;

    // Stores the properties for this avatar.
    AvatarProperties myAvatarProperties = new
AvatarProperties();

    // Stores the target position for this avatar.
    AvatarProperties targetAvatarProperties = new
AvatarProperties();

    // Audio.
    AudioSource soundAngry;
    AudioSource soundAfraid;
    AudioSource soundDisgust;
    AudioSource soundSad;
    AudioSource soundHappy;

    // Use this for initialization
    void Start () {
        // Add the transform for the attached object.
        This object should be the base model.
        allChildren.Add(transform);
    }
}
```

```

        // Next look for child components (e.g.
cloths, hair, etc). These should be tagged
        // With "Avatar".
        foreach(Transform aChild in transform){
            if(aChild.tag.Equals("Avatar")){
                allChildren.Add(aChild);
            }
        }

        // Set the default behaviour.
        currentState = AvatarConstants.Stand_Idle;
        currentEvent = AvatarConstants.onEnter;

        // Set the start position.

        myAvatarProperties.setPositionX(transform.position.
x);

        myAvatarProperties.setPositionY(transform.position.
y);

        myAvatarProperties.setPositionZ(transform.position.
z);

        // Load the audio files.

        soundAngry =
(AudioSource)gameObject.AddComponent("AudioSource");
        soundAngry.clip =
(AudioClip)Resources.Load("Sounds/angrysound");

        soundAfraid =
(AudioSource)gameObject.AddComponent("AudioSource");
        soundAfraid.clip =
(AudioClip)Resources.Load("Sounds/afraidsound");

        soundDisgust =
(AudioSource)gameObject.AddComponent("AudioSource");
        soundDisgust.clip =
(AudioClip)Resources.Load("Sounds/disgustsound");

        soundSad =
(AudioSource)gameObject.AddComponent("AudioSource");
        soundSad.clip =
(AudioClip)Resources.Load("Sounds/sadsound");

        soundHappy =
(AudioSource)gameObject.AddComponent("AudioSource");
        soundHappy.clip =
(AudioClip)Resources.Load("Sounds/happysound");

```

```

        // Load the image files.

        // Test the file.
        //soundAfraid.Play();

        /*
        // Check what has been found.
        foreach(Transform aChild in allChildren){
            print(aChild.name);
        }
        */

        // Enter a test command here...
        //this.setState(AvatarConstants.Sad, false);

        this.setState(AvatarConstants.Move_To_Target,
        false, new Vector3(10.0f, 1.6f, 10.0f) );
        //this.setState(AvatarConstants.Sad , true);

    }

    // Update is called once per frame
    void Update () {
        // Check if state change and should run on
        exit code. If yes to all set event to onExit.
        if(nextStateSet){
            if(runOnExitCodeForCurrentState){
                currentEvent =
AvatarConstants.onExit;
            }
        }

        // State machine.
        switch(currentState){

            // >>> ANIMATIONS <<<

            // Standing and Idle.
            case AvatarConstants.Stand_Idle:
                // On Enter.
                if(currentEvent ==
AvatarConstants.onEnter){

```



```

        this.playCrossFadeAnimation(AvatarConstants.Ani_Idle, 0.5f);
        currentEvent =
AvatarConstants.onUpdate;
    }
    // On Update.
    if(currentEvent ==
AvatarConstants.onUpdate){
        if(transform.animation.isPlaying ==
false){

            this.playAnimation(AvatarConstants.Ani_Idle);
        }
        // On Exit.
        if(currentEvent ==
AvatarConstants.onExit){

        }
        break;

        // Walk.
        case AvatarConstants.Walk:
            // On Enter.
            if(currentEvent ==
AvatarConstants.onEnter){

                this.playCrossFadeAnimation(AvatarConstants.Ani_Walk, 0.5f);
                currentEvent =
AvatarConstants.onUpdate;
            }
            // On Update.
            if(currentEvent ==
AvatarConstants.onUpdate){

            }
            // On Exit.
            if(currentEvent ==
AvatarConstants.onExit){

            }
            break;

            // Afraid.
            case AvatarConstants.Afraid:
                // On Enter.
                if(currentEvent ==
AvatarConstants.onEnter){
                    soundAfraid.Play();

```

```

        this.playCrossFadeAnimation(AvatarConstants.Ani_Afr
aid, 0.5f);

        // Play the sound.

        currentEvent =
AvatarConstants.onUpdate;
    }
    // On Update.
    if(currentEvent ==
AvatarConstants.onUpdate){
        if(transform.animation.isPlaying ==
false){
            // Exit the state.
            currentEvent =
AvatarConstants.onExit;
        }
    }
    // On Exit.
    if(currentEvent ==
AvatarConstants.onExit){
        currentState =
AvatarConstants.Stand_Idle;
        currentEvent =
AvatarConstants.onEnter;
    }
    break;

    // Happy.
    case AvatarConstants.Happy:
        // On Enter.
        if(currentEvent ==
AvatarConstants.onEnter){

            this.playCrossFadeAnimation(AvatarConstants.Ani_Hap
py, 0.3f);

            currentEvent =
AvatarConstants.onUpdate;

            // Play the sound.
            this.audio.clip = soundHappy.clip;
            audio.Play();
        }
        // On Update.
        if(currentEvent ==
AvatarConstants.onUpdate){
            if(transform.animation.isPlaying ==
false){
                // Exit the state.

```

```

                                currentEvent =
AvatarConstants.onExit;
                                }
                                }
                                // On Exit.
                                if(currentEvent ==
AvatarConstants.onExit){
                                    currentState =
AvatarConstants.Stand_Idle;
                                    currentEvent =
AvatarConstants.onEnter;
                                }
                                break;

                                // Sad.
                                case AvatarConstants.Sad:
                                    // On Enter.
                                    if(currentEvent ==
AvatarConstants.onEnter){

                                        this.playCrossFadeAnimation(AvatarConstants.Ani_Sad
, 0.5f);

                                        currentEvent =
AvatarConstants.onUpdate;

                                        // Play the sound.
                                        soundSad.Play();
                                    }
                                    // On Update.
                                    if(currentEvent ==
AvatarConstants.onUpdate){
                                        if(transform.animation.isPlaying ==
false){

                                            // Exit the state.
                                            currentEvent =
AvatarConstants.onExit;
                                        }
                                    }
                                    // On Exit.
                                    if(currentEvent ==
AvatarConstants.onExit){
                                        currentState =
AvatarConstants.Stand_Idle;
                                        currentEvent =
AvatarConstants.onEnter;
                                    }
                                    break;

                                // Disgust.
                                case AvatarConstants.Disgust:
                                    // On Enter.

```

```

        if(currentEvent ==
AvatarConstants.onEnter){

            this.playCrossFadeAnimation(AvatarConstants.Ani_Dis
gust, 0.5f);

                currentEvent =
AvatarConstants.onUpdate;

                    // Play the sound.
                    soundDisgust.Play();
                }
            // On Update.
            if(currentEvent ==
AvatarConstants.onUpdate){
                if(transform.animation.isPlaying ==
false){

                    // Exit the state.
                    currentEvent =
AvatarConstants.onExit;
                }
            }
            // On Exit.
            if(currentEvent ==
AvatarConstants.onExit){
                currentState =
AvatarConstants.Stand_Idle;
                currentEvent =
AvatarConstants.onEnter;
            }
            break;

            // Angry.
            case AvatarConstants.Angry:
                // On Enter.
                if(currentEvent ==
AvatarConstants.onEnter){

                    this.playCrossFadeAnimation(AvatarConstants.Ani_Ang
ry, 0.5f);

                        currentEvent =
AvatarConstants.onUpdate;

                            // Play the sound.
                            soundAngry.Play();

                                // Show image.

                                    }
                                // On Update.

```

```

        if(currentEvent ==
AvatarConstants.onUpdate){
            if(transform.animation.isPlaying ==
false){
                // Exit the state.
                currentEvent =
AvatarConstants.onExit;
            }
        }
        // On Exit.
        if(currentEvent ==
AvatarConstants.onExit){
            currentState =
AvatarConstants.Stand_Idle;
            currentEvent =
AvatarConstants.onEnter;
        }
        break;

// >>> MOVEMENT AND ANIMATIONS <<<

// Move to target.
case AvatarConstants.Move_To_Target:
    // On Enter.
    if(currentEvent ==
AvatarConstants.onEnter){
        if(targetSet == true){
            // Move to update event.
            currentEvent =
AvatarConstants.onUpdate;
        } else {
            // Exit the state.
            currentEvent =
AvatarConstants.onExit;
        }
    }
    // On Update.
    if(currentEvent ==
AvatarConstants.onUpdate){
        KinematicSteeringOutput
aKinematicSteeringOutput;

        aKinematicSteeringOutput =
MovementAlgorithms.KinematicSeek(myAvatarProperties,
targetAvatarProperties);

        MovementAlgorithms.UpdateKinematic(ref
myAvatarProperties, aKinematicSteeringOutput,
Time.deltaTime);

```

```

        // Update the game object.
        transform.position =
myAvatarProperties.getPosition();
        transform.rotation =
Quaternion.Euler(0, (90 +
myAvatarProperties.getOrientationInDegrees() ) ,0);

        // Param: ani, crossfade time, ani
speed.

        this.playCrossFadeAnimation(AvatarConstants.Ani_Walk, 0.5f, 1.0f);

        //this.playAnimation(AvatarConstants.Ani_Walk,
0.5f);

        if( this.distanceToTarget() < 1.0f){
            // Exit the state.
            currentEvent =
AvatarConstants.onExit;
        }
        // On Exit.
        if(currentEvent ==
AvatarConstants.onExit){
            currentState =
AvatarConstants.Stand_Idle;
            currentEvent =
AvatarConstants.onEnter;
        }
        break;

        // END OF CASE.
    } // CASE END.

    // Check if state change and should run on
exit code. If yes change state.
    if(nextStateSet){
        currentState = nextState;
        currentEvent = AvatarConstants.onEnter;
        nextStateSet = false;
    }

}

// Play AND Cross Fades animations.
private void playCrossFadeAnimation(string ani,
float crossFadeTime){
    playCrossFadeAnimation(ani, crossFadeTime,
1.0f);

```

```

    }

    // Play AND Cross Fades animations.
    private void playCrossFadeAnimation(string ani,
float crossFadeTime, float aniSpeed){
        foreach(Transform aChild in allChildren){
            aChild.animation.CrossFade(ani,
crossFadeTime);
            aChild.animation[ani].speed = aniSpeed;
        }
    }

    // Play animation.
    private void playAnimation(string ani){
        playAnimation(ani, 1.0f);
    }

    // Play animation AND Set Speed.
    private void playAnimation(string ani, float
aniSpeed){
        foreach(Transform aChild in allChildren){
            aChild.animation.Play(ani);
            aChild.animation[ani].speed = aniSpeed;
        }
    }

    // Play animation AND always loop.
    private void playAnimationLoop(string ani){
        foreach(Transform aChild in allChildren){
            aChild.animation.wrapMode =
WrapMode.Loop;
            aChild.animation.Play(ani);
        }
    }

    // Play animation always ONCE.
    private void playAnimationOnce(string ani){
        foreach(Transform aChild in allChildren){
            aChild.animation.wrapMode =
WrapMode.Once;
            aChild.animation.Play(ani);
        }
    }

    // Get the distance to a target.
    private float distanceToTarget(){
        Vector3 tmp = new Vector3();

        // Main seek code. First get a vector in the
direciton of the target.

```

```

        tmp.x = targetAvatarProperties.getPosition().x
- myAvatarProperties.getPosition().x;
        tmp.y = targetAvatarProperties.getPosition().y
- myAvatarProperties.getPosition().y;
        tmp.z = targetAvatarProperties.getPosition().z
- myAvatarProperties.getPosition().z;

        // Find the magnitude / length of the velocity
vector.
        float magnitude = Mathf.Sqrt( (tmp.x * tmp.x +
                                         tmp.y * tmp.y +
                                         tmp.z * tmp.z)
);

        return magnitude;
    }

    // >>> PUBLIC INTERFACE <<<

    // Set the state of the avatar.
    public void setState(int nextState, bool
runOnExitCodeForCurrentState, Vector3 target){
        targetAvatarProperties.setPositionX(target.x);
        targetAvatarProperties.setPositionY(target.y);
        targetAvatarProperties.setPositionZ(target.z);

        targetSet = true;

        setState(nextState,
runOnExitCodeForCurrentState);
    }

    // Set the state of the avatar.
    public void setState(int nextState, bool
runOnExitCodeForCurrentState){
        nextStateSet = true;
        this.nextState = nextState;
        this.runOnExitCodeForCurrentState =
runOnExitCodeForCurrentState;
    }

    // Get the current state.
    public int getState(){
        return currentState;
    }

    // Get the current event.
    public int getEvent(){
        return currentEvent;
    }
}

```


DROOLS (JAVA) - Main code for selecting a response based on personality and emotions

```
package com.sample;

import org.drools.KnowledgeBase;
import org.drools.KnowledgeBaseFactory;
import org.drools.builder.KnowledgeBuilder;
import org.drools.builder.KnowledgeBuilderError;
import org.drools.builder.KnowledgeBuilderErrors;
import org.drools.builder.KnowledgeBuilderFactory;
import org.drools.builder.ResourceType;
import org.drools.io.ResourceFactory;
import org.drools.logger.KnowledgeRuntimeLogger;
import org.drools.runtime.StatefulKnowledgeSession;

public class EVAVirtualHospital {

    public static final void main(String[] args) {

        float calculation = 0 + 1 + (5+1+1)/15f;
        System.out.println(calculation + "==" + Math.max (
            1,
                Math.min(
                    5,
                    Math.round(calculation)
                )
            ));

        System.setProperty("drools.dialect.mvel.strict",
            "false");

        EVAVirtualHospital evaVH = new
            EVAVirtualHospital();

        String personalityRulesFilename =
            "EVA_VH_PERSONALITY_1.drl";
        String scenarioRulesFilename =
            "EVA_VH_NO_EMOTION_CALC_RULES.drl";

        EVAVirtualHospital.RequestResponse reqResp = new
            EVAVirtualHospital.RequestResponse(
                "Q1",
                "Q1A1",
                "Q1A1T1",
                "Stress",
                1f,
                "Agitation",
```

```

        1f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A1",
        "Q1A1T1",
        "Stress",
        1f,
        "Agitation",
        1f,
        "VeryLowNeuroticism",
        false,
        2.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A1",
        "Q1A1T1",
        "Stress",
        5f,
        "Agitation",
        1f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);

```

```

        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

        reqResp = new EVAVirtualHospital.RequestResponse(
            "Q1",
            "Q1A1",
            "Q1A1T1",
            "Stress",
            1f,
            "Agitation",
            5f,
            "VeryLowNeuroticism",
            false,
            1.0f
        );

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

        reqResp = new EVAVirtualHospital.RequestResponse(
            "Q1",
            "Q1A1",
            "Q1A1T1",
            "Stress",
            5f,
            "Agitation",
            5f,
            "VeryLowNeuroticism",
            false,
            1.0f
        );

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

        reqResp = new EVAVirtualHospital.RequestResponse(

```

```

        "Q1",
        "Q1A1",
        "Q1A1T1",
        "Stress",
        1f,
        "Agitation",
        5f,
        "VeryHighNeuroticism",
        false,
        1.0f
    );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
        personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

        reqResp = new EVAVirtualHospital.RequestResponse(
            "Q1",
            "Q1A1",
            "Q1A1T1",
            "Stress",
            3f,
            "Agitation",
            3f,
            "VeryLowNeuroticism",
            false,
            1.0f
        );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
        personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

        reqResp = new EVAVirtualHospital.RequestResponse(
            "Q1",
            "Q1A1",
            "Q1A1T1",
            "Stress",
            3f,
            "Agitation",
            3f,

```

```

        "LowNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A1",
        "Q1A1T1",
        "Stress",
        1f,
        "Agitation",
        1f,
        "VeryHighNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A1",
        "Q1A1T1",
        "Stress",
        1f,
        "Agitation",
        2f,
        "VeryHighNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);

```

```

        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A2",
        "Q1A2T1",
        "Stress",
        1f,
        "Agitation",
        1f,
        "VeryLowNeuroticism",
        false,
        2.0f
    );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A2",
        "Q1A2T1",
        "Stress",
        5f,
        "Agitation",
        1f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A2",
    "Q1A2T1",
    "Stress",
    1f,
    "Agitation",
    5f,
    "VeryLowNeuroticism",
    false,
    1.0f
);

System.out.println(reqResp);
evaVH.executeRules(reqResp,
personalityRulesFilename);
System.out.println(reqResp);
evaVH.executeRules(reqResp, scenarioRulesFilename);
System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A2",
    "Q1A2T1",
    "Stress",
    5f,
    "Agitation",
    5f,
    "VeryLowNeuroticism",
    false,
    1.0f
);

System.out.println(reqResp);
evaVH.executeRules(reqResp,
personalityRulesFilename);
System.out.println(reqResp);
evaVH.executeRules(reqResp, scenarioRulesFilename);
System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A2",
    "Q1A2T1",
    "Stress",
    1f,

```

```

        "Agitation",
        5f,
        "VeryHighNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
        personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A2",
        "Q1A2T1",
        "Stress",
        3f,
        "Agitation",
        3f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
        personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A2",
        "Q1A2T1",
        "Stress",
        3f,
        "Agitation",
        3f,
        "LowNeuroticism",
        false,
        1.0f
    );

```



```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A2",
        "Q1A2T1",
        "Stress",
        1f,
        "Agitation",
        1f,
        "VeryHighNeuroticism",
        false,
        1.0f
        );

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A2",
        "Q1A2T1",
        "Stress",
        1f,
        "Agitation",
        2f,
        "VeryHighNeuroticism",
        false,
        1.0f
        );

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A3",
    "Q1A3T1",
    "Stress",
    1f,
    "Agitation",
    1f,
    "VeryLowNeuroticism",
    false,
    2.0f
);

System.out.println(reqResp);
evaVH.executeRules(reqResp,
personalityRulesFilename);
System.out.println(reqResp);
evaVH.executeRules(reqResp, scenarioRulesFilename);
System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A3",
    "Q1A3T1",
    "Stress",
    5f,
    "Agitation",
    1f,
    "VeryLowNeuroticism",
    false,
    1.0f
);

System.out.println(reqResp);
evaVH.executeRules(reqResp,
personalityRulesFilename);
System.out.println(reqResp);
evaVH.executeRules(reqResp, scenarioRulesFilename);
System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A3",
    "Q1A3T1",
    "Stress",

```

```

        1f,
        "Agitation",
        5f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
    personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A3",
        "Q1A3T1",
        "Stress",
        5f,
        "Agitation",
        5f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

    System.out.println(reqResp);
    evaVH.executeRules(reqResp,
    personalityRulesFilename);
    System.out.println(reqResp);
    evaVH.executeRules(reqResp, scenarioRulesFilename);
    System.out.println(reqResp);

    reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A3",
        "Q1A3T1",
        "Stress",
        1f,
        "Agitation",
        5f,
        "VeryHighNeuroticism",
        false,
        1.0f
    );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
        personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A3",
        "Q1A3T1",
        "Stress",
        3f,
        "Agitation",
        3f,
        "VeryLowNeuroticism",
        false,
        1.0f
    );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
        personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);
        System.out.println(reqResp);

```

```

reqResp = new EVAVirtualHospital.RequestResponse(
        "Q1",
        "Q1A3",
        "Q1A3T1",
        "Stress",
        3f,
        "Agitation",
        3f,
        "LowNeuroticism",
        false,
        1.0f
    );

```

```

        System.out.println(reqResp);
        evaVH.executeRules(reqResp,
        personalityRulesFilename);
        System.out.println(reqResp);
        evaVH.executeRules(reqResp, scenarioRulesFilename);

```

```

System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A3",
    "Q1A3T1",
    "Stress",
    1f,
    "Agitation",
    1f,
    "VeryHighNeuroticism",
    false,
    1.0f
);

System.out.println(reqResp);
evaVH.executeRules(reqResp,
personalityRulesFilename);
System.out.println(reqResp);
evaVH.executeRules(reqResp, scenarioRulesFilename);
System.out.println(reqResp);

reqResp = new EVAVirtualHospital.RequestResponse(
    "Q1",
    "Q1A3",
    "Q1A3T1",
    "Stress",
    1f,
    "Agitation",
    2f,
    "VeryHighNeuroticism",
    false,
    1.0f
);

System.out.println(reqResp);
evaVH.executeRules(reqResp,
personalityRulesFilename);
System.out.println(reqResp);
evaVH.executeRules(reqResp, scenarioRulesFilename);
System.out.println(reqResp);

}

```

```

        public EVAVirtualHospital.RequestResponse
        executeRules(EVAVirtualHospital.RequestResponse reqResp,
        String drlFile)
        {
            KnowledgeRuntimeLogger logger = null;
            StatefulKnowledgeSession ksession = null;
            try
            {
                // load up the knowledge base
                KnowledgeBase kbase =
                readKnowledgeBase(drlFile);
                ksession =
                kbase.newStatefulKnowledgeSession();
                //logger =
                KnowledgeRuntimeLoggerFactory.newFileLogger(ksession,
                "C:/scenarioLogs/drools.log");
                // go !
                ksession.insert(reqResp);
                ksession.fireAllRules();
            } catch (Throwable t) {
                t.printStackTrace();
            }
            finally
            {
                if (ksession!=null)
                {
                    ksession.dispose();
                }
                if (logger!=null)
                {
                    logger.close();
                }
            }

            return reqResp;
        }

        private KnowledgeBase readKnowledgeBase(String
        drlFile) throws Exception {
            KnowledgeBuilder kbuilder =
            KnowledgeBuilderFactory.newKnowledgeBuilder();

            kbuilder.add(ResourceFactory.newClassPathResource(drlFil
            e), ResourceType.DRL);
            KnowledgeBuilderErrors errors =
            kbuilder.getErrors();
            if (errors.size() > 0) {
                for (KnowledgeBuilderError error: errors) {
                    System.err.println(error);
                }
            }
        }

```

```

        throw new IllegalArgumentException("Could
not parse knowledge.");
    }
    KnowledgeBase kbase =
KnowledgeBuilderFactory.newKnowledgeBase();

kbase.addKnowledgePackages(kbuilder.getKnowledgePackages
());

    return kbase;

}

```

```

public static class RequestResponse
{

```

```

    private String questionId;
    private String answerId;
    private String answerTextId;
    private String emotion;
    private float  emotionScale;
    private String emotion2;
    private float  emotion2Scale;

    private String personality;
    private String feedback;
    private boolean correct = false;
    private float  patientReaction = 0;

```

```

    public RequestResponse(String questionId, String
answerId, String answerTextId, String emotion,
float emotionScale, String emotion2,
float emotion2Scale, String personality, boolean
correct, float patientReaction) {
        super();
        this.questionId = questionId;
        this.answerId = answerId;
        this.answerTextId = answerTextId;
        this.emotion = emotion;
        this.emotionScale = emotionScale;
        this.emotion2 = emotion2;
        this.emotion2Scale = emotion2Scale;
        this.personality = personality;
        this.correct = correct;
        this.patientReaction = patientReaction;

    }

```

```

    public String getQuestionId() {

```

```

        return questionId;
    }

    public void setQuestionId(String questionId) {
        this.questionId = questionId;
    }

    public String getAnswerId() {
        return answerId;
    }

    public void setAnswerId(String answerId) {
        this.answerId = answerId;
    }

    public String getAnswerTextId() {
        return answerTextId;
    }

    public void setAnswerTextId(String
answerTextId) {
        this.answerTextId = answerTextId;
    }

    public String getEmotion() {
        return emotion;
    }

    public void setEmotion(String emotion) {
        this.emotion = emotion;
    }

    public float getEmotionScale() {
        return emotionScale;
    }

    public void setEmotionScale(float
emotionScale) {
        this.emotionScale = emotionScale;
    }

```



```

    public String getEmotion2() {
        return emotion2;
    }

    public void setEmotion2(String emotion2) {
        this.emotion2 = emotion2;
    }

    public float getEmotion2Scale() {
        return emotion2Scale;
    }

    public void setEmotion2Scale(float
emotion2Scale) {
        this.emotion2Scale = emotion2Scale;
    }

    public String getPersonality() {
        return personality;
    }

    public void setPersonality(String personality)
{
        this.personality = personality;
    }

    public String getFeedback() {
        return feedback;
    }

    public void setFeedback(String feedback) {
        this.feedback = feedback;
    }

    public boolean isCorrect() {
        return correct;
    }

    public void setCorrect(boolean correct) {
        this.correct = correct;
    }

```

```

        public float getPatientReaction() {
            return patientReaction;
        }

        public void setPatientReaction(float
patientReaction) {
            this.patientReaction = patientReaction;
        }

        @Override
        public String toString() {
            return "RequestResponse [questionId=" +
questionId + ", answerId="
                                + answerId + ", answerTextId="
+ answerTextId
                                + ", emotion=" + emotion + ",
emotionScale=" + emotionScale
                                + ", emotion2=" + emotion2 + ",
emotion2Scale="
                                + emotion2Scale + ",
personality=" + personality
                                + ", feedback=" + feedback + ",
correct=" + correct
                                + ", patientReaction=" +
patientReaction + "]";
        }
    }
}

```

DROOLS (JAVA) - Rules script

```

package com.sample

import com.sample.EVAVirtualHospital.RequestResponse;

rule "personality='LowNeuroticism'"
    dialect "mvel"
    no-loop
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(personality=="LowNeur
oticism")
    then

        requestResponse.setEmotionScale(requestResponse.getEmoti
onScale() + 2);
        update(requestResponse);
    end

```

```

rule "personality='VeryLowNeuroticism'"
    dialect "mvel"
    no-loop
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(personality=="VeryLow
Neuroticism")
    then

requestResponse.setEmotionScale(requestResponse.getEmoti
onScale() + 1);
        update(requestResponse);
    end

rule "personality='AverageNeuroticism'"
    dialect "mvel"
    no-loop
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(personality=="Average
Neuroticism")
    then

requestResponse.setEmotionScale(requestResponse.getEmoti
onScale() + 0);
        update(requestResponse);
    end

rule "personality='HighNeuroticism'"
    dialect "mvel"
    no-loop
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(personality=="HighNeu
roticism")
    then

requestResponse.setEmotionScale(requestResponse.getEmoti
onScale() - 1);
    end

rule "personality='VeryHighNeuroticism'"
    dialect "mvel"
    no-loop
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(personality=="VeryHig
hNeuroticism")
    then

```

```

requestResponse.setEmotionScale(requestResponse.getEmoti
onScale() - 2);
end

```

```

rule "Q1-A1-T1-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A1", answerTextId == "Q1A1T1", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q1A1T1F1");
    end
end

```

```

rule "Q1-A1-T1-Stress>3&<=6"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A1", answerTextId == "Q1A1T1", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A1T1F2");
        requestResponse.setCorrect(false);
    end
end

```

```

rule "Q1-A1-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A1", answerTextId == "Q1A1T1", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A1T1F3");
        requestResponse.setCorrect(false);
    end
end

```

```

rule "Q1-A1-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q1",

```

```

answerId == "Q1A1", answerTextId == "Q1A1T2", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q1A1T2F1");
    end
end

```

```

rule "Q1-A1-T2-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A1", answerTextId == "Q1A1T2", emotion ==
        "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A1T2F2");
        requestResponse.setCorrect(false);
    end
end

```

```

rule "Q1-A1-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A1", answerTextId == "Q1A1T2", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A1T2F3");
        requestResponse.setCorrect(false);
    end
end

```

```

rule "Q1-A1-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A1", answerTextId == "Q1A1T3", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q1A1T3F1");
    end
end

```

```

rule "Q1-A1-T3-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",

```

```

answerId == "Q1A1", answerTextId == "Q1A1T3", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A1T3F2");
        requestResponse.setCorrect(false);
    end

rule "Q1-A1-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A1", answerTextId == "Q1A1T3", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A1T3F3");
        requestResponse.setCorrect(false);
    end

rule "Q1-A2-T1-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A2", answerTextId == "Q1A2T1", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q1A2T1F1");
    end

rule "Q1-A2-T1-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A2", answerTextId == "Q1A2T1", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A2T1F2");
        requestResponse.setCorrect(false);
    end

rule "Q1-A2-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A2", answerTextId == "Q1A2T1", emotion ==
"Stress", emotionScale >6)

```

```

        then
            requestResponse.setFeedback("Q1A2T1F3");
            requestResponse.setCorrect(false);
        end

rule "Q1-A2-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A2", answerTextId == "Q1A2T2", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q1A2T2F1");
    end

rule "Q1-A2-T2-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A2", answerTextId == "Q1A2T2", emotion ==
        "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A2T2F2");
        requestResponse.setCorrect(false);
    end

rule "Q1-A2-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A2", answerTextId == "Q1A2T2", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A2T2F3");
        requestResponse.setCorrect(false);
    end

rule "Q1-A2-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A2", answerTextId == "Q1A2T3", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);

```

```

        requestResponse.setFeedback("Q1A2T3F1");
    end

    rule "Q1-A2-T3-Stress>3&=<6"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q1",
            answerId == "Q1A2", answerTextId == "Q1A2T3", emotion ==
            "Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q1A2T3F2");
            requestResponse.setCorrect(false);
        end

    rule "Q1-A2-T3-Stress>6"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q1",
            answerId == "Q1A2", answerTextId == "Q1A2T3", emotion ==
            "Stress", emotionScale >6)
        then
            requestResponse.setFeedback("Q1A2T3F3");
            requestResponse.setCorrect(false);
        end

    rule "Q1-A3-T1-Stress<=3"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q1",
            answerId == "Q1A3", answerTextId == "Q1A3T1", emotion ==
            "Stress", emotionScale <= 3)
        then
            requestResponse.setCorrect(true);
            requestResponse.setFeedback("Q1A3T1F1");
        end

    rule "Q1-A3-T1-Stress>3&=<6"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q1",
            answerId == "Q1A3", answerTextId == "Q1A3T1", emotion ==
            "Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q1A3T1F2");
            requestResponse.setCorrect(true);
        end

```



```

end

rule "Q1-A3-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A3", answerTextId == "Q1A3T1", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A3T1F3");
        requestResponse.setCorrect(true);
    end

rule "Q1-A3-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A3", answerTextId == "Q1A3T2", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q1A3T2F1");
    end

rule "Q1-A3-T2-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A3", answerTextId == "Q1A3T2", emotion ==
        "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A3T2F2");
        requestResponse.setCorrect(true);
    end

rule "Q1-A3-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q1",
        answerId == "Q1A3", answerTextId == "Q1A3T2", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A3T2F3");
        requestResponse.setCorrect(true);
    end

```

```

rule "Q1-A3-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A3", answerTextId == "Q1A3T3", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q1A3T3F1");
    end
end

```

```

rule "Q1-A3-T3-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A3", answerTextId == "Q1A3T3", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q1A3T3F2");
        requestResponse.setCorrect(true);
    end
end

```

```

rule "Q1-A3-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q1",
answerId == "Q1A3", answerTextId == "Q1A3T3", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q1A3T3F3");
        requestResponse.setCorrect(true);
    end
end

```

```

rule "Q2-A1-T1-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A1", answerTextId == "Q2A1T1", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q2A1T1F1");
    end
end

```

```

rule "Q2-A1-T1-Stress>3&=<6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A1", answerTextId == "Q2A1T1", emotion ==
        "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q2A1T1F2");
        requestResponse.setCorrect(false);
    end

rule "Q2-A1-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A1", answerTextId == "Q2A1T1", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q2A1T1F3");
        requestResponse.setCorrect(false);
    end

rule "Q2-A1-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A1", answerTextId == "Q2A1T2", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q2A1T2F1");
    end

rule "Q2-A1-T2-Stress>3&=<6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A1", answerTextId == "Q2A1T2", emotion ==
        "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q2A1T2F2");
        requestResponse.setCorrect(false);
    end

```

```

rule "Q2-A1-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q2",
    answerId == "Q2A1", answerTextId == "Q2A1T2", emotion ==
    "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q2A1T2F3");
        requestResponse.setCorrect(false);
    end

rule "Q2-A1-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q2",
    answerId == "Q2A1", answerTextId == "Q2A1T3", emotion ==
    "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q2A1T3F1");
    end

rule "Q2-A1-T3-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q2",
    answerId == "Q2A1", answerTextId == "Q2A1T3", emotion ==
    "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q2A1T3F2");
        requestResponse.setCorrect(false);
    end

rule "Q2-A1-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
    EVAVirtualHospital.RequestResponse(questionId == "Q2",
    answerId == "Q2A1", answerTextId == "Q2A1T3", emotion ==
    "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q2A1T3F3");
        requestResponse.setCorrect(false);
    end

rule "Q2-A2-T1-Stress<=3"
    dialect "mvel"

```

```

        when
            requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T1", emotion ==
"Stress", emotionScale <= 3)
            then
                requestResponse.setCorrect(false);
                requestResponse.setFeedback("Q2A2T1F1");
            end

rule "Q2-A2-T1-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T1", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q2A2T1F2");
            requestResponse.setCorrect(false);
        end

rule "Q2-A2-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T1", emotion ==
"Stress", emotionScale >6)
        then
            requestResponse.setFeedback("Q2A2T1F3");
            requestResponse.setCorrect(false);
        end

rule "Q2-A2-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T2", emotion ==
"Stress", emotionScale <= 3)
        then
            requestResponse.setCorrect(false);
            requestResponse.setFeedback("Q2A2T2F1");
        end

rule "Q2-A2-T2-Stress>3<=6"
    dialect "mvel"
    when

```

```

        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T2", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q2A2T2F2");
            requestResponse.setCorrect(false);
        end

rule "Q2-A2-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T2", emotion ==
"Stress", emotionScale >6)
        then
            requestResponse.setFeedback("Q2A2T2F3");
            requestResponse.setCorrect(false);
        end
    end

rule "Q2-A2-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T3", emotion ==
"Stress", emotionScale <= 3)
        then
            requestResponse.setCorrect(false);
            requestResponse.setFeedback("Q2A2T3F1");
        end
    end

rule "Q2-A2-T3-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A2", answerTextId == "Q2A2T3", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q2A2T3F2");
            requestResponse.setCorrect(false);
        end
    end

rule "Q2-A2-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",

```

```

answerId == "Q2A2", answerTextId == "Q2A2T3", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q2A2T3F3");
        requestResponse.setCorrect(false);
    end

rule "Q2-A3-T1-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A3", answerTextId == "Q2A3T1", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q2A3T1F1");
    end

rule "Q2-A3-T1-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A3", answerTextId == "Q2A3T1", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q2A3T1F2");
        requestResponse.setCorrect(true);
    end

rule "Q2-A3-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A3", answerTextId == "Q2A3T1", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q2A3T1F3");
        requestResponse.setCorrect(true);
    end

rule "Q2-A3-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A3", answerTextId == "Q2A3T2", emotion ==
"Stress", emotionScale <= 3)

```

```

        then
            requestResponse.setCorrect(true);
            requestResponse.setFeedback("Q2A3T2F1");
        end

rule "Q2-A3-T2-Stress>3&≤6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A3", answerTextId == "Q2A3T2", emotion ==
        "Stress", emotionScale >3 && emotionScale ≤6)
    then
        requestResponse.setFeedback("Q2A3T2F2");
        requestResponse.setCorrect(true);
    end

rule "Q2-A3-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A3", answerTextId == "Q2A3T2", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q2A3T2F3");
        requestResponse.setCorrect(true);
    end

rule "Q2-A3-T3-Stress≤3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A3", answerTextId == "Q2A3T3", emotion ==
        "Stress", emotionScale ≤ 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q2A3T3F1");
    end

rule "Q2-A3-T3-Stress>3&≤6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q2",
        answerId == "Q2A3", answerTextId == "Q2A3T3", emotion ==
        "Stress", emotionScale >3 && emotionScale ≤6)
    then

```



```

        requestResponse.setFeedback("Q2A3T3F2");
        requestResponse.setCorrect(true);
    end

    rule "Q2-A3-T3-Stress>6"
        dialect "mvel"
        when
            requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q2",
answerId == "Q2A3", answerTextId == "Q2A3T3", emotion ==
"Stress", emotionScale >6)
        then
            requestResponse.setFeedback("Q2A3T3F3");
            requestResponse.setCorrect(true);
        end
    end

```

```

    rule "Q3-A1-T1-Stress<=3"
        dialect "mvel"
        when
            requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A1", answerTextId == "Q3A1T1", emotion ==
"Stress", emotionScale <= 3)
        then
            requestResponse.setCorrect(false);
            requestResponse.setFeedback("Q3A1T1F1");
        end
    end

```

```

    rule "Q3-A1-T1-Stress>3<=6"
        dialect "mvel"
        when
            requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A1", answerTextId == "Q3A1T1", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q3A1T1F2");
            requestResponse.setCorrect(false);
        end
    end

```

```

    rule "Q3-A1-T1-Stress>6"
        dialect "mvel"
        when
            requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",

```

```

answerId == "Q3A1", answerTextId == "Q3A1T1", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A1T1F3");
        requestResponse.setCorrect(false);
    end

rule "Q3-A1-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A1", answerTextId == "Q3A1T2", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q3A1T2F1");
    end

rule "Q3-A1-T2-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A1", answerTextId == "Q3A1T2", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q3A1T2F2");
        requestResponse.setCorrect(false);
    end

rule "Q3-A1-T2-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A1", answerTextId == "Q3A1T2", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A1T2F3");
        requestResponse.setCorrect(false);
    end

rule "Q3-A1-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A1", answerTextId == "Q3A1T3", emotion ==
"Stress", emotionScale <= 3)

```

```

        then
            requestResponse.setCorrect(false);
            requestResponse.setFeedback("Q3A1T3F1");
        end

rule "Q3-A1-T3-Stress>3&≤6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A1", answerTextId == "Q3A1T3", emotion ==
        "Stress", emotionScale >3 && emotionScale ≤6)
    then
        requestResponse.setFeedback("Q3A1T3F2");
        requestResponse.setCorrect(false);
    end

rule "Q3-A1-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A1", answerTextId == "Q3A1T3", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A1T3F3");
        requestResponse.setCorrect(false);
    end

rule "Q3-A2-T1-Stress≤3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A2", answerTextId == "Q3A2T1", emotion ==
        "Stress", emotionScale ≤ 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q3A2T1F1");
    end

rule "Q3-A2-T1-Stress>3&≤6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A2", answerTextId == "Q3A2T1", emotion ==
        "Stress", emotionScale >3 && emotionScale ≤6)
    then

```

```

        requestResponse.setFeedback("Q3A2T1F2");
        requestResponse.setCorrect(false);
    end

    rule "Q3-A2-T1-Stress>6"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q3",
            answerId == "Q3A2", answerTextId == "Q3A2T1", emotion ==
            "Stress", emotionScale >6)
        then
            requestResponse.setFeedback("Q3A2T1F3");
            requestResponse.setCorrect(false);
        end

    rule "Q3-A2-T2-Stress<=3"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q3",
            answerId == "Q3A2", answerTextId == "Q3A2T2", emotion ==
            "Stress", emotionScale <= 3)
        then
            requestResponse.setCorrect(false);
            requestResponse.setFeedback("Q3A2T2F1");
        end

    rule "Q3-A2-T2-Stress>3<=6"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q3",
            answerId == "Q3A2", answerTextId == "Q3A2T2", emotion ==
            "Stress", emotionScale >3 && emotionScale <=6)
        then
            requestResponse.setFeedback("Q3A2T2F2");
            requestResponse.setCorrect(false);
        end

    rule "Q3-A2-T2-Stress>6"
        dialect "mvel"
        when
            requestResponse :
            EVAVirtualHospital.RequestResponse(questionId == "Q3",
            answerId == "Q3A2", answerTextId == "Q3A2T2", emotion ==
            "Stress", emotionScale >6)
        then
            requestResponse.setFeedback("Q3A2T2F3");
            requestResponse.setCorrect(false);
        end

```

```

end

rule "Q3-A2-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A2", answerTextId == "Q3A2T3", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(false);
        requestResponse.setFeedback("Q3A2T3F1");
    end

rule "Q3-A2-T3-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A2", answerTextId == "Q3A2T3", emotion ==
        "Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q3A2T3F2");
        requestResponse.setCorrect(false);
    end

rule "Q3-A2-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A2", answerTextId == "Q3A2T3", emotion ==
        "Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A2T3F3");
        requestResponse.setCorrect(false);
    end

rule "Q3-A3-T1-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
        EVAVirtualHospital.RequestResponse(questionId == "Q3",
        answerId == "Q3A3", answerTextId == "Q3A3T1", emotion ==
        "Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q3A3T1F1");
    end

```

```

rule "Q3-A3-T1-Stress>3&=<6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T1", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q3A3T1F2");
        requestResponse.setCorrect(true);
    end

rule "Q3-A3-T1-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T1", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A3T1F3");
        requestResponse.setCorrect(true);
    end

rule "Q3-A3-T2-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T2", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q3A3T2F1");
    end

rule "Q3-A3-T2-Stress>3&=<6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T2", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q3A3T2F2");
        requestResponse.setCorrect(true);
    end

rule "Q3-A3-T2-Stress>6"

```

```

        dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T2", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A3T2F3");
        requestResponse.setCorrect(true);
    end

rule "Q3-A3-T3-Stress<=3"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T3", emotion ==
"Stress", emotionScale <= 3)
    then
        requestResponse.setCorrect(true);
        requestResponse.setFeedback("Q3A3T3F1");
    end

rule "Q3-A3-T3-Stress>3<=6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T3", emotion ==
"Stress", emotionScale >3 && emotionScale <=6)
    then
        requestResponse.setFeedback("Q3A3T3F2");
        requestResponse.setCorrect(true);
    end

rule "Q3-A3-T3-Stress>6"
    dialect "mvel"
    when
        requestResponse :
EVAVirtualHospital.RequestResponse(questionId == "Q3",
answerId == "Q3A3", answerTextId == "Q3A3T3", emotion ==
"Stress", emotionScale >6)
    then
        requestResponse.setFeedback("Q3A3T3F3");
        requestResponse.setCorrect(true);
    end

```

SCENARIO SERVER - SAMPLE SCENARIO (XML)

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Feedback Text</text>

        </feedback>
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Feedback Text</text>

    </feedback>
</feedbacks>

```

```

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Answer</text>

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Feedback Text</text>

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Feedback Text</text>

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Feedback Text</text>

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Answer</text>

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Feedback Text</text>

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```

```

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```



```

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Answer</text>

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Feedback Text</text>

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Feedback Text</text>

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Answer</text>

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                            <id>Q3A1T2F3</id>
                            <text>Q3A1T2F3
Feedback Text</text>

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```

```

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Answer</text>

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Feedback Text</text>

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Feedback Text</text>

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Answer</text>

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Feedback Text</text>

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```

```

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Answer</text>
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Answer</text>

```

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```

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</answer>
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</question>
</questions>
</scenario>

```

SCENARIO SERVER - AnswerQuestion.java

```
package com.mihalis.scenarioserver;

import com.mihalis.scenarioserver.domain.Scenario;
import com.mihalis.scenarioserver.sessionsupport.AuditSupport;
import com.mihalis.scenarioserver.sessionsupport.DataStore;
import com.mihalis.scenarioserver.sessionsupport.ScenarioSupport;
import java.io.IOException;
import java.io.PrintWriter;
import java.util.Enumeration;
import javax.servlet.ServletException;
import javax.servlet.http.HttpServlet;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

public class AnswerQuestion extends HttpServlet {

    /**
     * Processes requests for both HTTP <code>GET</code>
and <code>POST</code>
     * methods.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    protected void processRequest(HttpServletRequest request, HttpServletResponse response)
        throws ServletException, IOException {

        Enumeration params =
request.getParameterNames();
        while (params.hasMoreElements())
        {
            String param = (String)params.nextElement();

            String paramValue = (String)
request.getParameter(param);
```

```

        System.out.println(param + "=" +
paramValue);

    }
    String uniqueId =
request.getParameter("uniqueId");
    String questionId = request.getParameter("qId");
    String questionText =
request.getParameter("questionText");
    String agentName =
request.getParameter("agentName");
    String emotion =
request.getParameter("emotion");
    String message =
request.getParameter("message");
    String selectedAnswerTextId =
request.getParameter("selectedAnswerTextId");
    String selectedAnswerText =
request.getParameter("selectedAnswerText");
    String selectedAnswerId =
request.getParameter("selectedAnswerId");
    String personality =
request.getParameter("personality");
    String emotionScale =
request.getParameter("eScale");
    String emotion2 =
request.getParameter("emotion2");
    String emotion2Scale =
request.getParameter("e2Scale");
    DataStore dataStore = (DataStore)
request.getSession().getServletContext().getAttribute("D
ATASTORE");

    response.setContentType("text/plain;charset=UTF-
8");

    String reply = processAnswer(uniqueId,
questionId, selectedAnswerId, selectedAnswerTextId,
emotion, Float.valueOf(emotionScale), emotion2,
Float.valueOf(emotion2Scale), personality, dataStore);
    System.out.println("Feedback: " + reply);

    try
    {
        StringBuffer auditLogLine = new
StringBuffer();
        auditLogLine.append(agentName);
        auditLogLine.append("|");
        auditLogLine.append(personality);
        auditLogLine.append("|");

```

```

        auditLogLine.append(emotion);
        auditLogLine.append("|");
        auditLogLine.append(emotionScale);
        auditLogLine.append("|");
        auditLogLine.append(emotion2);
        auditLogLine.append("|");
        auditLogLine.append(emotion2Scale);
        auditLogLine.append("|");
        auditLogLine.append(questionId);
        auditLogLine.append("|");
        auditLogLine.append(questionText);
        auditLogLine.append("|");
        auditLogLine.append(selectedAnswerId);
        auditLogLine.append("|");
        auditLogLine.append(selectedAnswerTextId);
        auditLogLine.append("|");
        auditLogLine.append(selectedAnswerText);

        AuditSupport.append("c:\\scenarioLogs\\" +
uniqueId+".log", auditLogLine.toString(), true);
        AuditSupport.append("c:\\scenarioLogs\\" +
uniqueId+".log", reply, true);
    }
    catch (Exception e)
    {
        e.printStackTrace();
    }

    PrintWriter out = response.getWriter();
    try {
        out.println(reply);
    } finally {
        out.close();
    }
}

private String processAnswer(String uniqueId, String
questionId, String answerId, String answerTextId, String
emotion, float emotionScale, String emotion2, float
emotion2Scale, String personality, DataStore datastore)
{
    Scenario scenario = null;
    String nextFeedback = null;

    try {
        scenario =
ScenarioSupport.getScenarioFromXMLFile(getServletConfig(
).getServletContext().getResourceAsStream("WEB-
INF/Scenario1.xml"));

```



```

        } catch (Exception ex) {
            ex.printStackTrace();
        }

        FeedBackHolder feedbackHolder =
ScenarioSupport.getFeedbackDecisionFromRules(questionId,
answerId, answerTextId, emotion, emotionScale, emotion2,
emotion2Scale, personality);
        String feedbackId =
feedbackHolder.getFeedback();
        boolean isCorrectAnswer =
feedbackHolder.isIsAnswerCorrect();

        nextFeedback =
ScenarioSupport.getFeedbackAsDelimitedString(questionId,
answerId, answerTextId, feedbackId, scenario);
        datastore.add(uniqueId,
"currentQuestionCorrect", isCorrectAnswer);
        return nextFeedback;
    }
    // <editor-fold defaultstate="collapsed"
desc="HttpServlet methods. Click on the + sign on the
left to edit the code.">
    /**
     * Handles the HTTP <code>GET</code> method.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    @Override
    protected void doGet(HttpServletRequest request,
HttpServletResponse response)
        throws ServletException, IOException {
        processRequest(request, response);
    }

    /**
     * Handles the HTTP <code>POST</code> method.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    @Override

```

```

        protected void doPost(HttpServletRequest request,
        HttpServletResponse response)
            throws ServletException, IOException {
            processRequest(request, response);
        }

        /**
         * Returns a short description of the servlet.
         *
         * @return a String containing servlet description
         */
        @Override
        public String getServletInfo() {
            return "Short description";
        } // </editor-fold>
    }

```

SCENARIO SERVER - NextQuestion.java

```
package com.mihalis.scenarioserver;

import com.mihalis.scenarioserver.domain.Scenario;
import com.mihalis.scenarioserver.sessionsupport.DataStore;
import com.mihalis.scenarioserver.sessionsupport.ScenarioSupport;
import java.io.IOException;
import java.io.PrintWriter;
import javax.servlet.ServletException;
import javax.servlet.http.HttpServlet;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

public class NextQuestion extends HttpServlet {

    /**
     * Processes requests for both HTTP GET
and POST
     * methods.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    protected void processRequest(HttpServletRequest request, HttpServletResponse response)
        throws ServletException, IOException {

        String uniqueUserId = (String)
request.getParameter("uniqueId");
        DataStore dataStore = (DataStore)
request.getSession().getServletContext().getAttribute("DATASTORE");

        String currentQuestion = (String)
dataStore.get(uniqueUserId, "currentQuestion");
        Boolean currentQuestionCorrect = (Boolean)
dataStore.get(uniqueUserId, "currentQuestionCorrect");
        response.setContentType("text/plain;charset=UTF-8");

        PrintWriter out = response.getWriter();
        try {
```

```

        String nextQuestionId =
getNextQuestionId(currentQuestion,
currentQuestionCorrect);
        dataStore.add(uniqueUserId,
"currentQuestion", nextQuestionId);
        String nextQuestionString =
getQuestion(nextQuestionId);
        out.print(nextQuestionString);
        System.out.println("Next Question string for
" + uniqueUserId + ": " + nextQuestionString);

    } finally {
        out.close();
    }
}

private String getNextQuestionId(String
currentQuestionId, Boolean currentQuestionCorrect) {
    String nextQuestionId = "";
    switch (currentQuestionId) {
        case "START":
            nextQuestionId = "1";
            break;
        default:
            if
(Boolean.TRUE.equals(currentQuestionCorrect)) {
                nextQuestionId =
Integer.valueOf(Integer.valueOf(currentQuestionId) +
1).toString();
            } else {
                nextQuestionId =
Integer.valueOf(Integer.valueOf(currentQuestionId)).toSt
ring();
            }
    }
    return nextQuestionId;
}

private String getQuestion(String questionId) {
    Scenario scenario = null;
    String nextQuestion = null;

    try {
        scenario =
ScenarioSupport.getScenarioFromXMLFile(getServletConfig(
).getServletContext().getResourceAsStream("WEB-
INF/Scenario1.xml"));
        String nextQuestionId = "Q" + questionId;
        nextQuestion =
ScenarioSupport.getQuestionAsBarDelimitedString(scenario
, nextQuestionId);
    }

```

```

        } catch (Exception ex) {
            ex.printStackTrace();
        }
        return nextQuestion;
    }

    // <editor-fold defaultstate="collapsed"
    desc="HttpServlet methods. Click on the + sign on the
    left to edit the code.">
    /**
     * Handles the HTTP <code>GET</code> method.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
    error occurs
     * @throws IOException if an I/O error occurs
     */
    @Override
    protected void doGet(HttpServletRequest request,
    HttpServletResponse response)
        throws ServletException, IOException {
        processRequest(request, response);
    }

    /**
     * Handles the HTTP <code>POST</code> method.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
    error occurs
     * @throws IOException if an I/O error occurs
     */
    @Override
    protected void doPost(HttpServletRequest request,
    HttpServletResponse response)
        throws ServletException, IOException {
        processRequest(request, response);
    }

    /**
     * Returns a short description of the servlet.
     *
     * @return a String containing servlet description
     */
    @Override
    public String getServletInfo() {
        return "Short description";
    } // </editor-fold>

```

}

SCENARIO SERVER - SetPersonality.java

```
package com.mihalis.scenarioserver;

import java.io.IOException;
import java.io.PrintWriter;
import javax.servlet.ServletException;
import javax.servlet.http.HttpServlet;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

public class SetPersonality extends HttpServlet {

    /**
     * Processes requests for both HTTP <code>GET</code>
and <code>POST</code>
     * methods.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    protected void processRequest(HttpServletRequest
request, HttpServletResponse response)
        throws ServletException, IOException {
        response.setContentType("text/html;charset=UTF-
8");
        PrintWriter out = response.getWriter();
        try {
            /* TODO output your page here. You may use
following sample code. */
            out.println("<!DOCTYPE html>");
            out.println("<html>");
            out.println("<head>");
            out.println("<title>Servlet
SetPersonality</title>");
            out.println("</head>");
            out.println("<body>");
            out.println("<h1>Servlet SetPersonality at "
+ request.getContextPath() + "</h1>");
            out.println("</body>");
            out.println("</html>");
        } finally {
            out.close();
        }
    }
}
```

```

    // <editor-fold defaultstate="collapsed"
desc="HttpServlet methods. Click on the + sign on the
left to edit the code.">
    /**
     * Handles the HTTP <code>GET</code> method.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    @Override
    protected void doGet(HttpServletRequest request,
HttpServletResponse response)
        throws ServletException, IOException {
        processRequest(request, response);
    }

    /**
     * Handles the HTTP <code>POST</code> method.
     *
     * @param request servlet request
     * @param response servlet response
     * @throws ServletException if a servlet-specific
error occurs
     * @throws IOException if an I/O error occurs
     */
    @Override
    protected void doPost(HttpServletRequest request,
HttpServletResponse response)
        throws ServletException, IOException {
        processRequest(request, response);
    }

    /**
     * Returns a short description of the servlet.
     *
     * @return a String containing servlet description
     */
    @Override
    public String getServletInfo() {
        return "Short description";
    } // </editor-fold>
}

```


SCENARIO SERVER - TestScenario.java

```
package com.mihalis.scenarioserver.domain;

import java.io.File;
import java.io.FileOutputStream;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;
import javax.xml.bind.JAXBContext;
import javax.xml.bind.Marshaller;
import javax.xml.bind.Unmarshaller;

public class Test {

    public static void main(String[] args) throws
Exception {

        JAXBContext context =
JAXBContext.newInstance(Scenario.class);
        Marshaller marshaller =
context.createMarshaller();
        Scenario scenario = new Scenario();
        List<Question> questions = createQuestionList(3,
Arrays.asList("Stress", "Anger"));
        scenario.setQuestions(questions);
        scenario.setId("S1");
        scenario.setScenarioName("Scenario 1");

        String filename = "c:\\temp\\scenario1.xml";

        marshaller.setProperty(Marshaller.JAXB_FORMATTED_OUTPUT,
Boolean.TRUE);
        marshaller.marshal(scenario, new
FileOutputStream(filename));

        Unmarshaller unmarshaller =
context.createUnmarshaller();
        scenario = (Scenario)unmarshaller.unmarshal(new
File(filename));

    }

    public static List<Question> createQuestionList(int
numberOfQuestions, List<String> emotions) {

        List<Question> questions = new ArrayList<>();

        for (int i = 0; i < numberOfQuestions; i++) {
```

```

        Question question = new Question();
        String questionId = "Q" + (i + 1);
        question.setId(questionId);
        question.setQuestionText(questionId + "
Text");
        question.setEmotions(emotions);

        List<Answer> answerList =
createAnswerList(3, 3, 3, questionId);
        question.setAnswers(answerList);
        questions.add(question);
    }
    return questions;
}

    public static List<Answer> createAnswerList(int
numberOfAnswers, int numberOfPossibleAnswerTexts, int
numberOfPossibleFeedbacks, String questionId) {

        List<Answer> answers = new ArrayList<>();

        for (int i = 0; i < numberOfAnswers; i++) {
            Answer answer = new Answer();
            String answerId = questionId + "A" + (i+1);
            answer.setId(answerId);

            List<AnswerText> possibleAnswerTexts =
createAnswerTextList(numberOfPossibleAnswerTexts,
numberOfPossibleFeedbacks, answerId);

            answer.setPossibleAnswerTexts(possibleAnswerTexts);
            answers.add(answer);
        }

        return answers;
    }

    public static List<AnswerText>
createAnswerTextList(int numberOfAnswerTexts, int
numberOfPossibleFeedbacks, String answerId) {
        List<AnswerText> answerTexts = new
ArrayList<>();

        for (int j = 0; j < numberOfAnswerTexts;
j++) {
            AnswerText answerText = new
AnswerText();
            String answerTextId = answerId + "T" +
(j+1);
            answerText.setId(answerTextId);

```

```

        String text = answerTextId + " Possible
Answer";
        answerText.setText(text);

        List feedbackList =
createFeedbackList(numberOfPossibleFeedbacks,
answerTextId);
        answerText.setFeedbacks(feedbackList);

        answerTexts.add(answerText);
    }

    return answerTexts;
}

public static List<Feedback> createFeedbackList(int
numberOfFeedbacks, String answerId) {

    List<Feedback> feedbacks = new ArrayList<>();

    for (int i = 0; i < numberOfFeedbacks; i++) {
        Feedback feedback = new Feedback();
        String feedbackId = answerId + "F" + (i+1);
        feedback.setId(feedbackId);
        feedback.setText(feedbackId + " Feedback
Text");
        feedbacks.add(feedback);
    }

    return feedbacks;
}
}

```